Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

AUGUST 1951

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PP51-7

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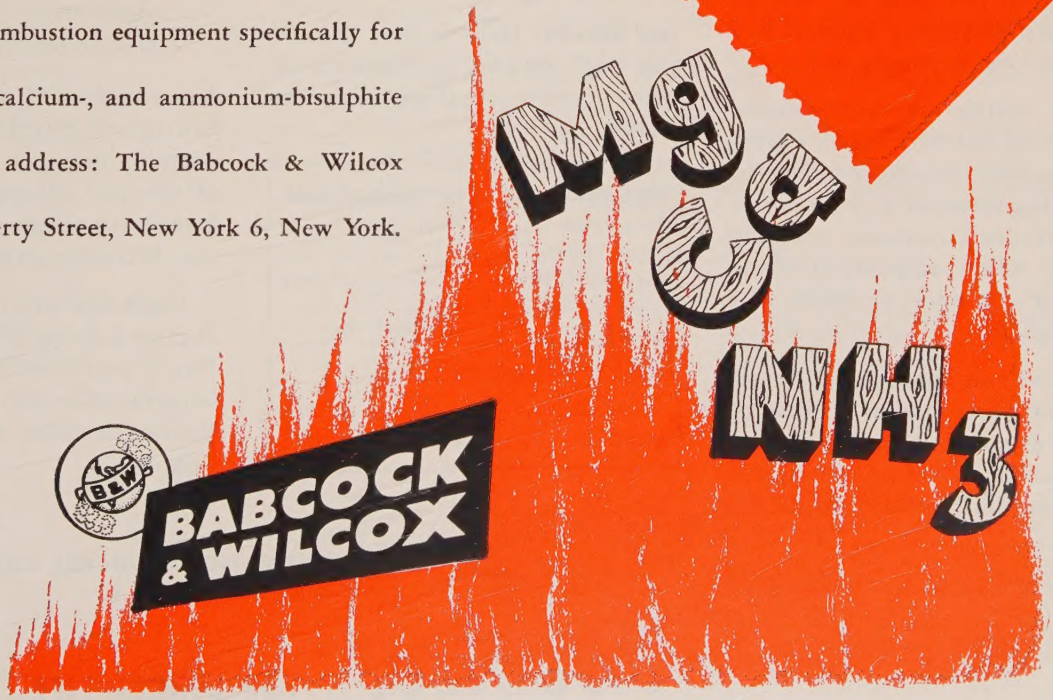
Another Example of B & W Research for Savings



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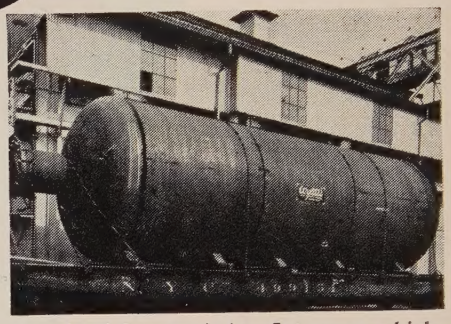
P-759

Interior of Lukens Inconel-Clad Steel digester, manufactured for Crossett Paper Mills by Wyatt Metal & Boiler Works, P. O. Box 3052, Houston 1, Texas.

Inconel

PROMISES INCREASED DIGESTER LIFE

. . . at Crossett Paper Mills



Completed digester tied to flat car on which it travelled from Texas to Arkansas.

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For some unexplained reason, corrosion caused their mild steel digesters to fail after as little as four years. Previously digesters had lasted as long as twenty years.

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Duration of Test . . . . . 35 days

Material	Corrosion Rate	
	mdd.	ipy
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Mild Steel	420	.077

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2. Plant-installed lining of Inconel sheet or strip for existing digesters.
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AUGUST 1951

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VOL. 34 · NO. 8

Published monthly by the Technical Association of the Pulp and Paper Industry

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Published monthly by the Technical Association of the Pulp and Paper Industry at 20th and Northampton Streets, Easton, Pa. Editorial and advertising offices, 122 East 42nd Street, New York 17, N. Y. Articles for publication and communications regarding the editorial content of *Tappi* should be addressed to the Editor at the editorial office. Statements and opinions expressed in articles and editorials appearing in *Tappi* are those of the contributors, and the Technical Association of the Pulp and Paper Industry assumes no responsibility for them. Subscription: U. S. and possessions, $7.50; Canada, $8.25; Pan American Union, $9.00; Other Foreign, $10.00. Single copies to members of TAPPI, $0.75; Nonmembers, $1.00. Entered as second class matter January 27, 1949, at the Post Office at Easton, Pa., under the act of August 24, 1912. Copyright, 1951, by the Technical Association of the Pulp and Paper Industry. An index of the technical articles appearing in the magazine appears in the Industrial Arts Index and the Engineering Index.

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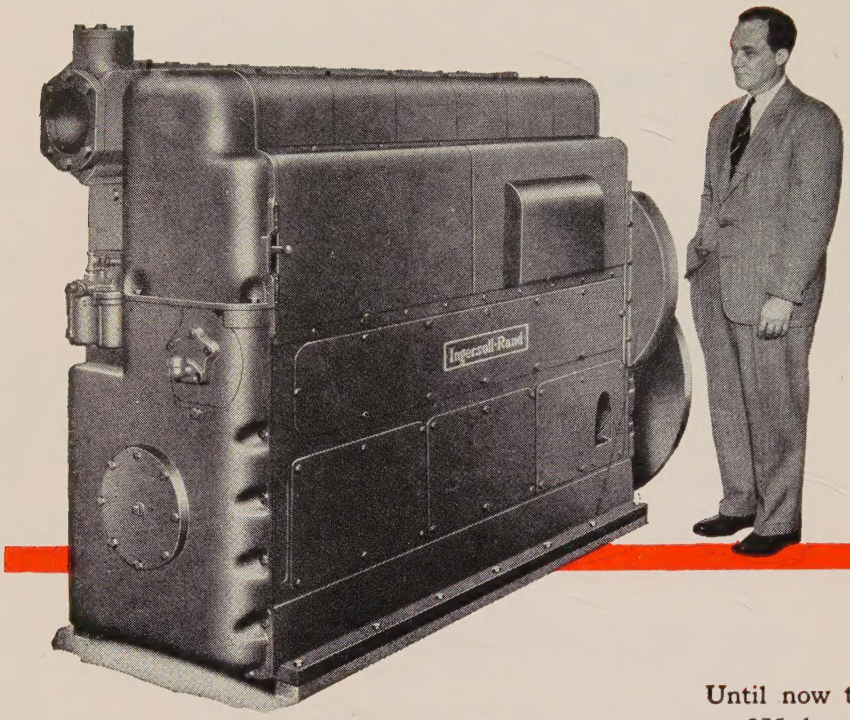

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Reciprocal Paper-Plastics Developments

EDWIN C. JAHN

THE relation of plastics to paper is well described by the word reciprocal, meaning complementary or, in mathematics, a function or expression so related to another that their product is unity. Unity, expressed in the finished paper product, is nowadays very often the result of a combination of paper fibers and plastics, their respective properties complementing each other to develop new qualities suited for special purposes.

GROWTH OF THE PLASTICS INDUSTRY

Plastics was not an important material in the paper industry until very recently. This is not surprising since the plastics industry itself is young. Production of plastics during the decade 1939–49 increased fivefold, reaching $1^1/_4$ billion pounds in 1949 and jumping to nearly 2 billion pounds (1,841,000,000 pounds) in 1950 (*1*). These figures do not include the synthetic rubbers. This is a remarkable growth for any industry. But the growth in complexity of the industry and multiplicity of resins produced is equally dramatic. During the twenties "the phenolic and pyroxylin materials were the alpha and omega of the industry" (*2*). Then in rapid succession during the thirties came the development of cellulose acetate, urea-formaldehyde, the vinyl resins, the acrylic resins, polystyrene, synthetic rubbers, ethyl cellulose, and cellulose mixed esters, all of which are commonplace today.

During the decade just completed many new and outstanding resins were developed. The roll call includes nylon, polyethylene, polyfluoroethylenes, cellulose propionate, carboxymethylcellulose, hydroxyethyl cellulose, unsaturated polyesters, melamine-formaldehyde resins, furans, polyvinylidene chloride, styrene copolymers, acrylonitrile copolymers, epoxy resins, silicones, terpene resins, and many others.

Keeping pace with the development of new resins are the engineering developments in machines and processes. Outstanding developments (*3*) in fabricating techniques and new processes have been achieved during the past decade, thereby greatly expanding the use possibilities of the resin materials. These include electronic heating, blow molding, pulp molding, postforming of laminates, and low pressure laminating, just to name a few.

The nature of the plastics industry with respect to (1) the many resin materials produced, covering a multitude of different properties, and (2) the diversity of process and application techniques is reflected in the combination of plastics with paper. The breadth and variety of plastics-paper combinations are very extensive. The many resin materials available permit the development of paper combinations with a great diversity of properties. Furthermore, the developments in machines and equipment is constantly widening application techniques and processes. New resins, new machines, new paper applications, and new products are being added at almost a dizzy rate.

EDWIN C. JAHN, Director of Research and Professor of Forest Chemistry, State University of New York, College of Forestry, Syracuse 10, N. Y.

WHAT ARE PLASTIC MATERIALS?

Plastics belong to that group of materials having large molecules, i.e., high polymers. Dissecting the word polymer, we find that "mer" means part (in this case the simplest chemical-structural unit) and "poly," of course, means many. Hence, polymer implies a molecule containing many repeating parts. Plastics are divided into two broad groups (1) the thermosetting resins, which are heat-hardening and become irreversibly infusible when heated and (2) the thermoplastic resins, which either *per se* or with a suitable plasticizer exhibit continuous flow under heat and pressure, the change from the solid to a viscous liquid being reversible. Examples of the thermosetting type are the phenolics, urea resins, and vulcanized rubber. Examples of the thermoplastic group include the cellulose esters and ethers, unvulcanized rubber, polystyrene, etc. There is a special group of thermoplastic materials known as the elastomers, which are the unvulcanized natural and synthetic rubbers. The elastomers have high reversible extensibility.

METHODS OF APPLICATION OF RESINS TO PAPER

The first efforts to add resins or plastic substances to paper were to improve such properties as printability, writability, and gloss. Natural high polymers were used, such as rosin, starch, casein, and glues. This art is fairly old and developed slowly. With the advent of the synthetic resins, efforts were made to improve further the properties of paper and this led to the development of entirely new properties and products from paper-plastics combinations. The growth and development of the plastics industry, therefore, directly supplement and expand the paper industry.

A large number of techniques have been developed for applying plastics to paper. To a considerable extent the method of application depends upon the nature of the plastic and/or the desired end product. However, some plastics may be applied by two or more methods and likewise some products may be made by a variety of plastic application techniques. A general classification of methods of application is as follows:

Tub sizing—the glazing or partial penetration of the paper sheet.

Saturation—complete penetration of the paper sheet.

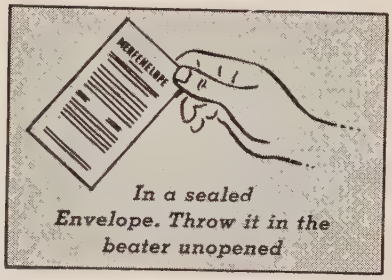
Beater addition—adding the plastic material in fine particles suspended in water to the pulp suspension in the beater or at some other point in the papermaking process.

Coating—this may be accomplished by knife coaters, roll coaters, the air knife coater, or cast coaters.

Film lamination—calendering a plastic film, such as a vinyl

Merfenelopes

FOR SLIME CONTROL



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TYPES OF PAPER-PLASTICS COMBINATIONS

Only a brief survey of paper-plastics combinations and their uses can be given in this short talk. I shall present this survey in the form of a convenient outline based on the types of products produced, namely sized paper, wet-strength papers, flexible boards, grease and moisture-resistant papers, coated papers, laminated papers, laminated structural products, and pulp-molded products.

Sized Papers

The sizing of papers by various natural substances such as rosin, starch, and casein is an old art. These materials are related to plastics in that they are high polymers, and they are still widely used. More recently some of the synthetic plastics have come into the picture and there is active research on new plastics sizing agents. Sizing is accomplished by the tub sizing or beater addition methods.

Wet-Strength Papers

Wet-strength papers, although a relatively new development, are already an accepted important commodity. Maps, toweling, wrappers, bags, and other items where wet strength is desired are manufactured. Thermosetting resins are used—mostly ureas and melamines, although phenolics are now coming into the picture. The resins are added to the stock in the beater, where they are first dispersed and then settle out on the fibers. A small quantity of these resins has a very marked effect on the wet strength of the paper.

Flexible Boards

Flexible boards are produced by saturating a soft, absorbent paper sheet with thermoplastic resins such as plasticized acrylates or vinyl compounds, or elastomers, including neoprene, thiokol, and other synthetic rubbers as well as natural rubber. The plastic is usually incorporated by a saturation process involving the passing of the paper sheet through a bath containing an emulsion or solution of the resin or elastomer. Many shoe parts (midsoles, insoles, sock linings, and quarter linings) and simulated leather products are made from saturated papers. These products are often subsequently coated with a resin such as cellulose nitrate to give a good surface. A flexible wallboard is also made by the film lamination process, whereby a vinyl copolymer film is calendered onto a sheet previously saturated with a suitable lower molecular weight copolymer. The product resembles leather.

Grease and Moisture-Resistant Papers

Functional papers having grease-resistance or moisture-resistance can be made by a number of techniques involving beater addition, tub sizing, or saturation. The type of resin employed depends upon the functional use desired. Some resins, such as polyethylene, are both grease and water-resistant. Other resins which may be used are the cellulose derivatives, nylon, neoprene, polystyrene, silicones, and polyesters.

Coated Papers

One of the most important applications of plastics to paper is in the field of coatings. A large number of machines and processes have been developed for applying a plastic coating to paper. Furthermore, the plastic material may be applied in different media, i.e., in water solution, as an emulsion in organic solvents, as plasticized dispersed pastes (vinyl copolymer organosols), as plasticized resins (vinyl copolymer plastisols), and as hot melts. There are two basic types of hot melts, one being a resin such as polyisobutylene, cyclized rubber, natural or synthetic rubber or coumarone-indene resins, blended with more than 50% of paraffin wax. The other is based on a cellulose derivative or other thermoplastic resin, which may be considered a type of lacquer and which is brought into coating condition by the use of heat instead of solvents.

The number of possible formulations of resins applied in the above media is almost unlimited. Practically all of the thermoplastic types are used. The emulsions or water dispersions include the elastomers, i.e., latices of natural or synthetic rubbers, as well as acrylic resins, polystyrene, polyvinyl acetate, and polyvinyl chloride. In solvent coating, the plastic is dissolved in an organic solvent and applied as a lacquer. Many resins are used including the cellulose derivatives, polyethylene, the natural and synthetic rubbers, polyamides, vinyl polymers, polystyrenes, polyacrylates, etc. For obtaining heavy coatings, the organosols (paste resins) or plastisols may be used.

Coatings are applied to papers to develop functional properties and for decorative purposes. The most important (*4*) functional properties are:

1. Heat sealability.
2. Structural strength.
3. Gas and water resistance.
4. Grease and oil resistance.
5. Mold resistance.
6. Chemical resistance.
7. Pressure sealability.
8. Flexibility.
9. Water resistance.
10. Solvent resistance.
11. Protection of printing or undercoat from heat.
12. Scuff resistance.

The decorative coatings obtained by coatings are gloss, color, and design. Specialty coatings may require other features—playing cards, for example, must not only have gloss, scuff-resistance, etc., but a pleasant "feel." Usually the coating must serve multiple functions.

Coated papers are widely used for packaging (wraps, bags, cartons, bottles, cups, frozen foods) for decorative uses, for seat covers, mats, belts, and many other purposes. Also the dividing line between coating and printing is a narrow one, the gravure printer can easily become a paper coater without many changes in equipment.

Laminated Papers

The laminants involve a specialized type of coating. A highly plasticized, tacky, nonhardening, flexible substance is coated on the paper by one of the paper coating processes. This forms a tacky adhesive surface so that the sheet may be laminated to another surface which is usually a clear film but may be another sheet of paper, a fabric, or a wood or metal surface. During

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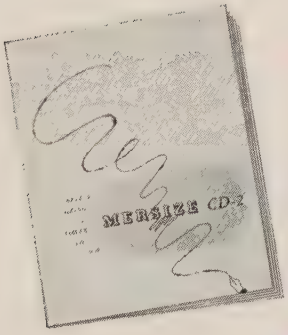

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the past decade there has been an increasing number of laminations of paper to plastic film such as polyethylene and saran. These products have many of the functional and decorative properties of the coated papers.

Laminated Structural Products

Laminated assemblies made from layers of paper impregnated with resin and bonded by heat form the basis for a large and thriving industry. These laminated products are widely used in the electrical and machine industries, for insulators, gears, pulleys, and a multitude of machine parts. They possess high impact strength and toughness, are not subject to corrosion, have a dampening effect on sound (eliminating rattle and drumming in steel cars and machinery), good electrical insulation, dimensional stability and high strength to weight ratio. They can also be easily manufactured into complex shapes and can be drilled, turned, and sawn. These properties make these products of great industrial value. They are also used in making trays, helmets, light flooring, containers, tubes, panels, decorative table and counter tops, and many other products.

The shortage of metals during the war greatly stimulated the development of laminated assemblies for machine and structural purposes (bazooka tubes, fuel tanks, airplane parts, etc.). A few years ago laminated assemblies were bonded at very high pressure, usually over 1000 p.s.i., requiring expensive molds and presses. Shortage of equipment during the war led to the development of low pressure and contact processes employing practically zero pressure. Another important development is in the making of lightweight, strong, highly insulating honeycomb sandwich panels and flooring. Paper-base laminates and honeycomb are finding broad new uses in building construction (*5*, *6*).

Paper for laminated assemblies must meet definite specifications. It must be strong, yet absorbent, and be of uniform formation. The paper is most often impregnated with the resin by a saturation process employing a resin dissolved in a suitable solvent. The introduction of the resin by the beater-addition process has now also been developed. The resins employed are of the thermosetting type, such as the phenolics, ureas, and melamines. However, newer thermosetting copolymers or cross-linked polyesters have been more recently introduced. Also lignin plastics are being used to some extent.

Pulp Molding

The molding of pulp to make picnic plates, toys, and many papier-maché articles in an old art. However, this art has been extended by the development of processes for incorporating or saturating resins into the preformed pulp and then subjecting the preform to a final molding under heat and pressure. Techniques for adding the resin and fixing it on the fiber in aqueous suspension have recently been developed. Thermosetting resins are used in this process. In this way very strong, tough, dimensionally stable articles can be made such as dishes, trays, toys, book ends, decoys, etc.

THE FUTURE

Probably in no field of paper technology is there as great development activity as in paper-plastic combinations. The plastics industry continues to contribute a host of new materials each year. As more new plastic materials are developed, the potential number of future materials is increased because of the increased possibilities for combinations and interreactions. Hand in hand with the development of plastics materials is research on their application to paper. New resins may mean new processes of application, modification of properties, development of new properties and new products.

At present there is research on the application of new copolymers to paper, such as the new elastomer-vinyl copolymers and of plasticized resins. Such resins are expected to give greater permanent flexibility to the product. New film laminations with polyethylene and saran are among other recent developments. There is no doubt in the minds of those acquainted with this field but that the 1950 decade will see paper plastics developments equally as great, if not surpassing those that have taken place during the past decade.

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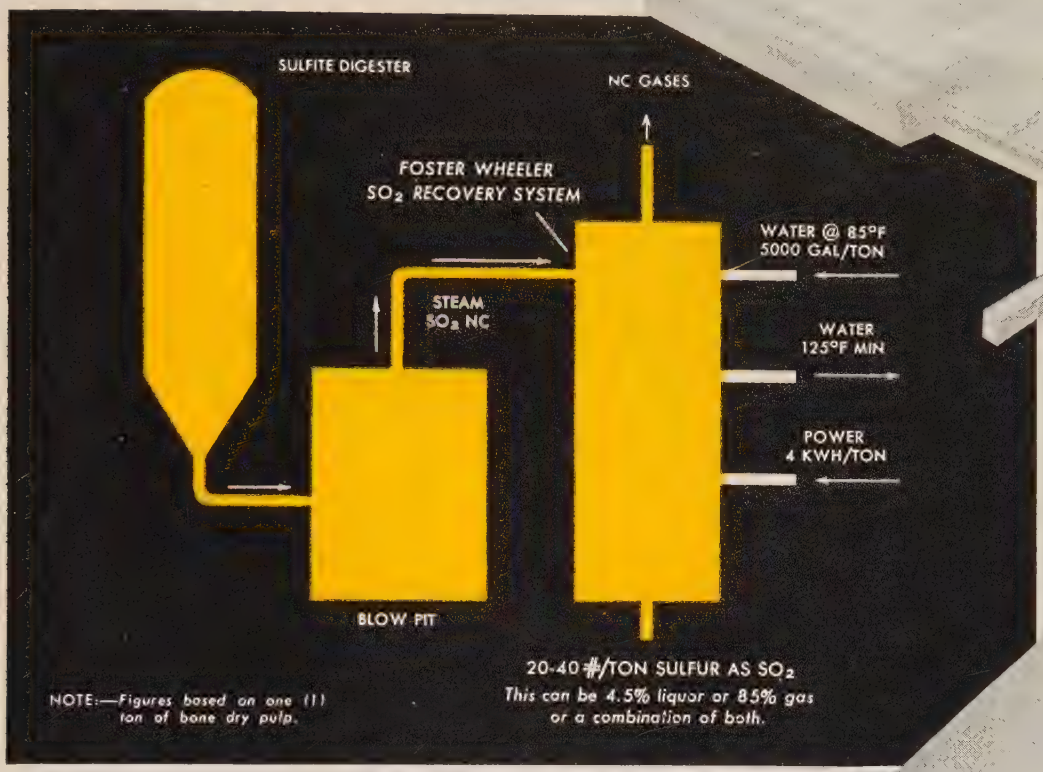
Prepared for Empire State TAPPI Meeting, Saranac Lake, N. Y., June 28–30, 1951. This paper is based on an address (unpublished) before the Materials Committee, American Paper and Pulp Association, New York, Feb. 22, 1950.

a Foster Wheeler system for . . .

sulfur and heat recovery from sulphite digester blow steam



The shortage of sulfur in the pulp and paper industry may now be lessened as the result of the development of an effective Sulfur Recovery system.

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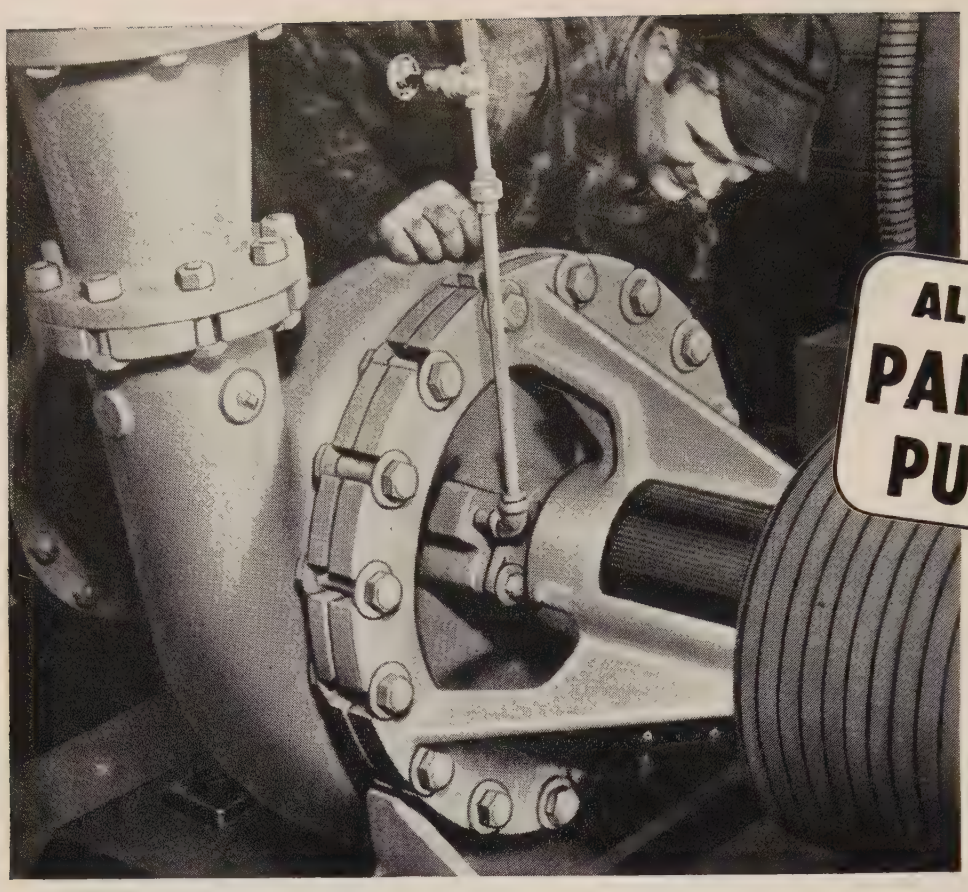

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SEE HOW EASY IT IS to work on the packing and clear water seal of this Allis-Chalmers Type PW Paper Stock Pump. And notice that the casing bolts are in slots instead of holes. This makes it possible to remove the rotating element in five minutes and replace it in the same quick time. Neither suction nor discharge piping need be disturbed. Thus maintenance is easy and fast, maintenance costs are low.

Heavy construction designed especially to withstand the loads imposed by pumping heavy stock and special materials to suit the characteristics of the stock being pumped keep the necessity for maintenance down. Many parts are interchangeable on several sizes of pumps so spare parts inventory is low regardless of the number of pumps you operate.

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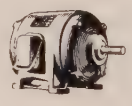
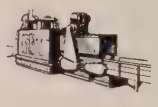
Allis-Chalmers pump representatives are thoroughly familiar with all types of paper making processes. One of these competent application engineers will be glad to help you with your pumping problems — or with your problems involving any other of the many paper making processes for which Allis-Chalmers manufactures equipment. Call your nearby Allis-Chalmers District Office, or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for bulletins 08B7112 and 08B6725. A-3406

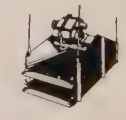


MOTORS



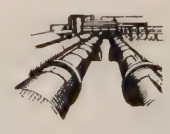
STREAMBARKER

TEXROPE V-BELT DRIVES



VIBRATING SCREENS

HI-DENSITY FEEDER



ROTARY KILNS

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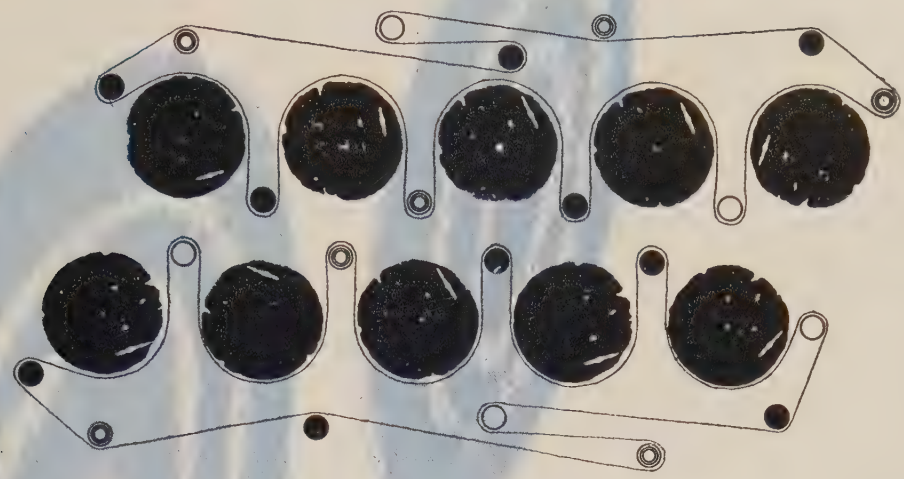

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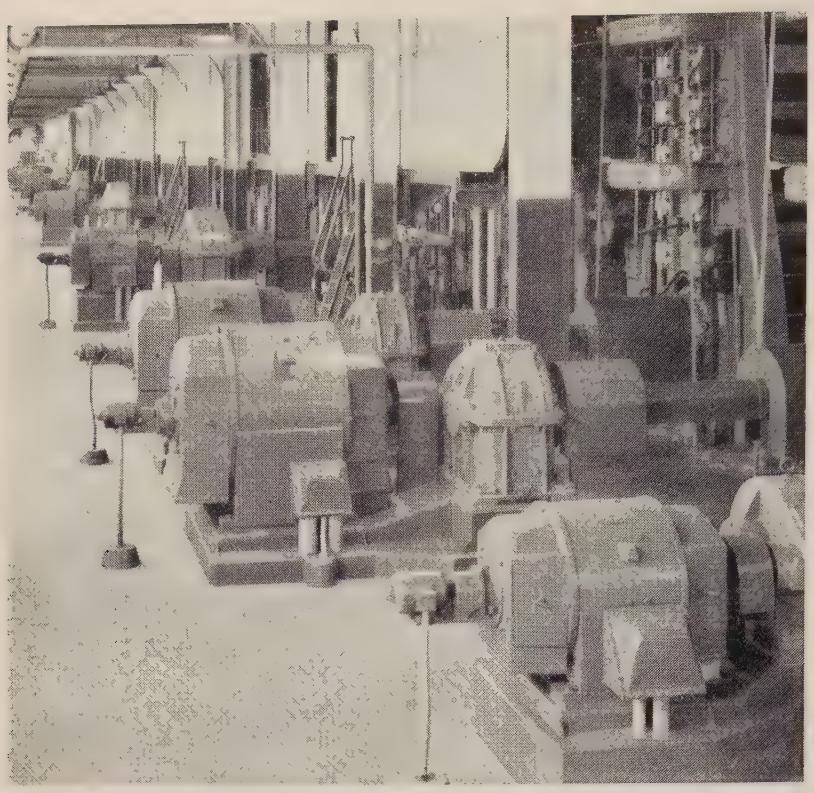
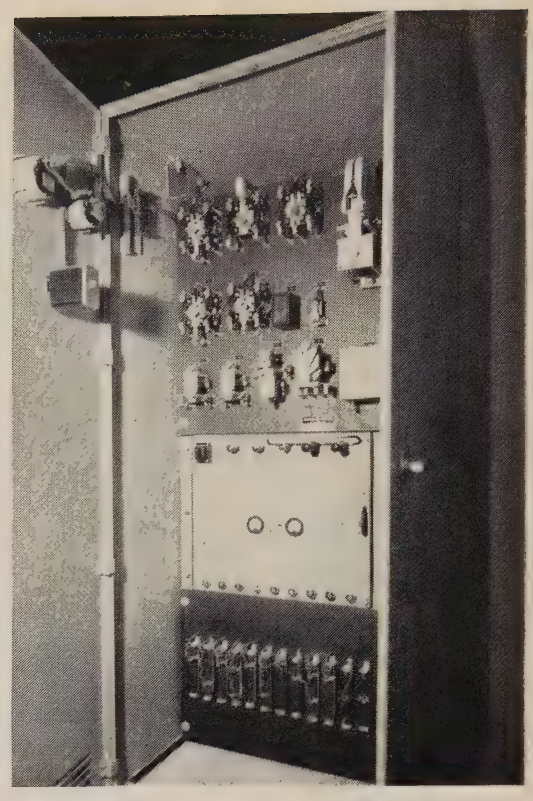
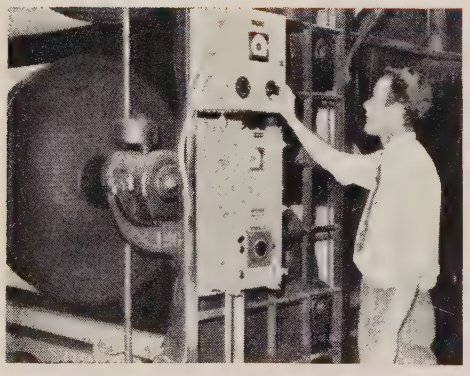


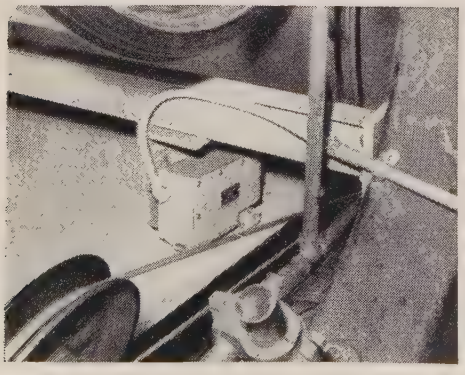
A co-ordinated but independent drive for each paper-machine section is provided by G-E multiple-generator sectional drive, which permits each section to operate at top efficiency with fast, accurate control. Shown here from the dry end is the G-E sectional drive at St. Regis Paper Co. in Tacoma, Wash.



Standardized circuits and simplified wiring in control panels permit faster installation and easier maintenance. Photo shows interior of a typical section control panel which includes electronic pre-amplifier, relays, contactors, and resistors.

Get high production

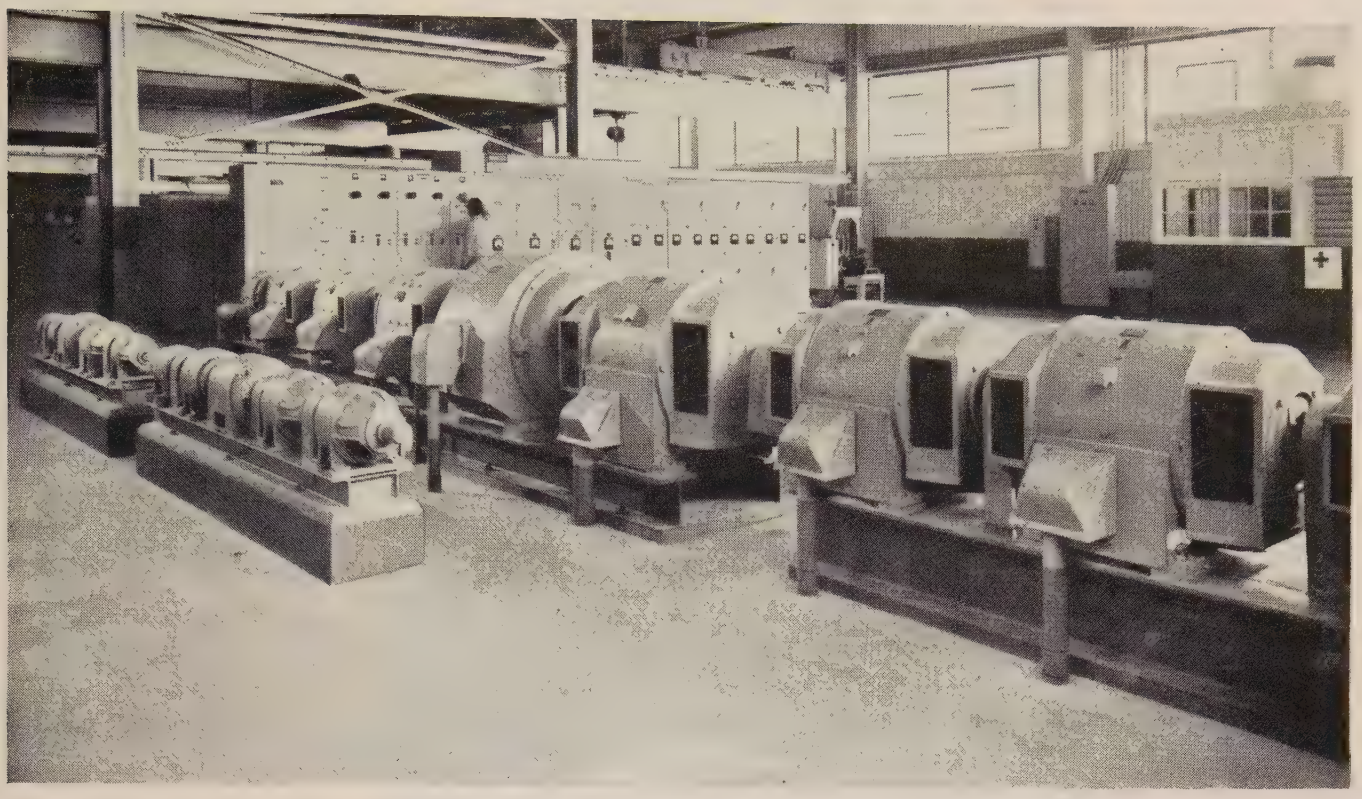




New G-E tensiometer reduces paper breaks, cuts down time!

A revolutionary new development, the G-E paper tensiometer prevents snap-offs caused by excess tension at dryer, calender and reel sections, reduces down time and broke, and helps increase output of uniform-quality rolls. Applicable to new or existing G-E electronic amplidyne sectional drives, it continuously regulates paper tension without damage to the sheet and with greater precision than otherwise possible. Equipment comprises operator's tension controls (top panel in upper photo) and tension head (lower photo). This installation at Ohio Boxboard Co., Rittman, Ohio, was added to an existing G-E drive. When engineered as automatic control into new drive systems, operator's tension controls are combined with the standard section operator's panel. For more data, write for Bulletin GEC-685.

CO-ORDINATED PAPER-MILL DRIVES



Multiple-generator system contributes to easy understanding, simple operation, and quick maintenance. Using a separate generator for each section eliminates the starting generator with its complicated switching that is characteristic of the single-generator system. Shown here, at the Fibreboard Products, Inc., mill at Antioch, Calif., are the G-E amplidyne sets (left) used as exciters for the G-E motor-generator sets (right). The amplidyne, with its fast response and high amplification factor, has been successfully used in over 800 paper-mill applications.

and a uniform sheet!

G-E multiple-generator sectional drive holds draw accurately between sections regardless of load changes—for higher speeds and less broke!

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Draw between sections is held accurately regardless of load changes, thus minimizing breaks, slack, or weaving at the reel. • Fast, accurate response of section speeds to draw adjustments eliminates guesswork from machine tender's "feel." • Adjustment of one section draw does not disturb other section draws, permitting quicker, more accurate draw changes. • Simple push-button control provides slack take-up for each section without affecting draw adjustments, thus reducing wrinkle-producing slack and calender cuts. • One or more sections may be started without shock to the whole system, and for wash-up and inspection, all sections may be run or jogged simultaneously at low speeds. • Over-all machine speed is easily adjusted from central master control panel.

Find out more about this production-boosting drive, representing more than 40 years of experience with the paper industry's specialized needs. Call your G-E representative today, or write for Bulletin GEA-5036. *General Electric Company, Schenectady 5, N. Y.*

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655-9

PULPWOOD SUPPLIES IN NEW YORK STATE

Papers Presented at the Annual Meeting of the Empire State Section, Lake Placid, N. Y., June 28, 1951

Industry's Role as Related to New York State's Pulpwood Supply

G. A. PESEZ

The pulp and paper industry of New York State faces a very great challenge. Its continued existence at present consumption levels of pulpwood is seriously threatened. This threat is that of raw material starvation. There is a very wide and unfavorable disparity between our annual cut of pulpwood and what our forests are replenishing through annual growth. This is not a recent condition, but one that has obtained for several years. However, in recent years this unbalanced situation has become increasingly disproportionate.

Today, the 30 odd pulp mills of New York are consuming approximately 1,000,000 cords of pulpwood annually. The national consumption for 1951 will be about 23,000,000 cords. Of the 1,000,000 cords used in New York mills, about 45% or nearly half will be imported from Canada, 20% or one fifth will be shipped in from neighboring New England States, and the balance or 35% will come from New York State. Therefore, we have the picture of an important and traditional state industry dependent on a foreign country and neighboring states to supply two thirds of its raw material. This is far from a satisfactory position for the pulp and paper industry in which to find itself. While there are no quotas on shipments of pulpwood from Canada, no pulpwood which was cut on Crown lands may be exported. Certain provinces are discouraging shipments of various raw materials, including pulpwood, hoping thereby to stimulate the production of finished products at home. Recently, Canada has been shipping increasing quantities of pulpwood abroad. It is obvious that these trends further aggravate available pulpwood supplies for export to New York State.

When we pause to survey the future of continued supplies of pulpwood at the present rate of about 200,000 cords annually from our neighboring states of Vermont, New Hampshire, and Maine, the prospects of maintaining this source of supply at present levels, let alone increasing it, are not very encouraging. These states are also harboring their resources for their own mills. Only a few of the larger companies, with woodlands in these neighboring states, can confidently plan on maintaining or increasing their present shipments from these sources.

Let us now examine the pulpwood resources of our own State of New York which at present is supplying but 35% of the needs of the consuming mills within the State.

Of the million cords, in round figures, used annually by New York mills, about 700,000 cords consist of spruce and balsam, 125,000 cords consist of poplar, 50,000 cords consist of hemlock, 75,000 cords consist of hardwood, and about 50,000 cords consist of pine. In excess of two thirds of our annual consumption consists of spruce and fir, both, of course, desirable, long-fibered woods which lend themselves readily to pulping by almost any process. Both are also comparatively slow-growing species, particularly spruce, and their natural growing range is confined to the Adirondack and Catskill regions. We are still drawing heavily from these original stands of spruce and fir, far in excess of what they are capable of producing through regrowth.

We have in our State about 11 million acres of commercial forests, exclusive of the Adirondack and Catskill Parks which total some $2^1/_2$ million acres. Small farm woodlots comprise 32% or about one third, other private holdings including paper company woodlands total 60%, and public holdings total 8%. The pulp and paper companies own about 650,000 acres or about 6% of the total commercial forest lands in the State. Only four companies own in excess of 100,000 acres each. It is doubtful if any company in the State is growing as much wood annually on its own holdings as it requires to maintain its mill in full production.

Many mills have no woodland holdings whatever, and are entirely dependent on imports and local purchases of pulpwood on the open market. Other companies with dwindling backlogs of wood also enter the open market for whatever wood is offered for sale, hoping thereby to stretch their own resources. The result is a highly competitive market for all pulpwood offered for sale. Some mills, which once were favorably located to wood supplies, now find themselves farther and farther away from available supplies with resultant heavy transportation costs on their raw material.

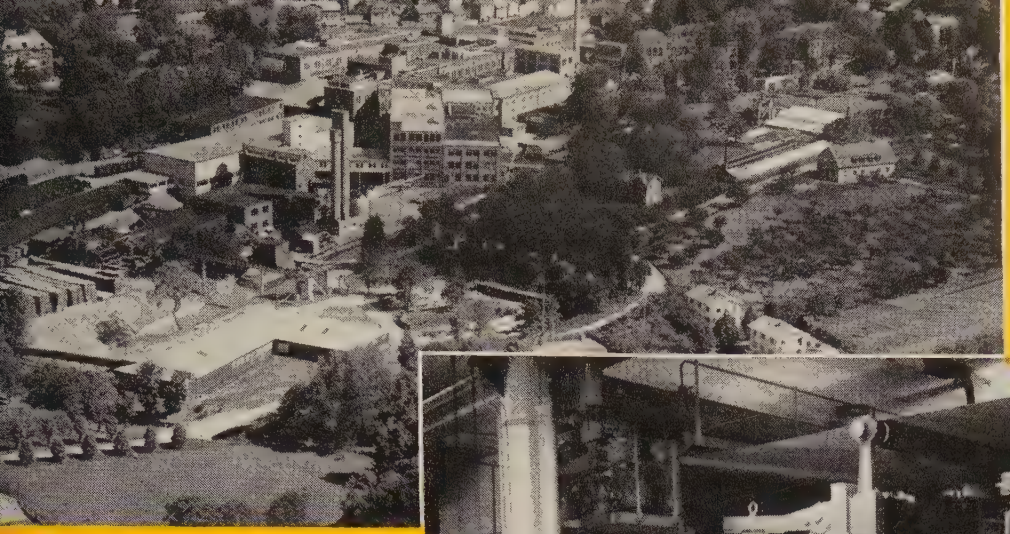
The big question is what can be done to obtain more adequate supplies of the desirable species of pulpwood for the mills of New York State. The pulp and paper industry has always been in the forefront of wood-using industries in the application of good forest management to its forest holdings. They have of course very heavy investments in permanently located mills which cannot be moved to the source of supply such as are sawmills. As a result they have a much greater stake in insuring continuous supplies of raw materials than do most other wood-using industries. Practically all of the pulp and paper companies today employ foresters who work out sound cutting practices aimed to keep the forest growing at maximum capacity. However, much remains to be done along these lines and further intensification of forest management policies by the pulp and paper industry is indicated.

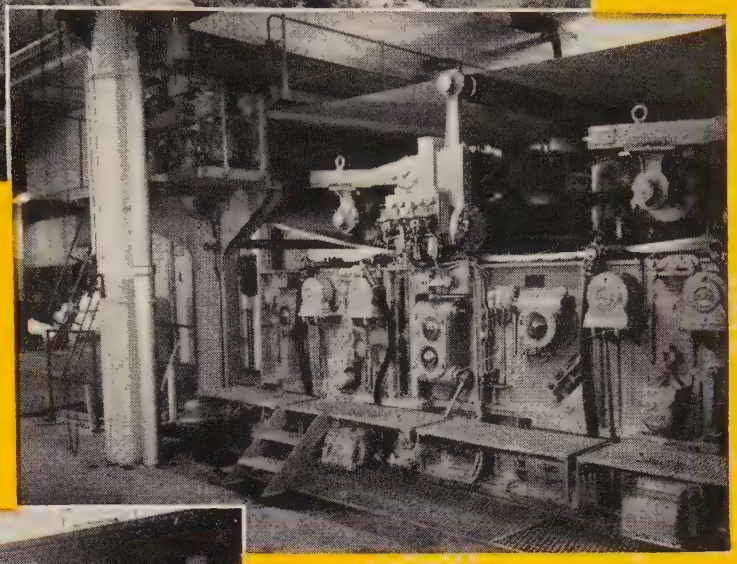
As stated previously, the pulp and paper companies own about 650,000 acres of timberlands in the State. It has been estimated that the total pulpwood requirements of the State's pulp and paper industry, could be grown on a sustained yield basis on 2 million acres of forest land. It would seem therefore that a logical step for industry to take would be to embark on a forest land acquisition program.

However, there are several deterrents to such a course. First, suitable and desirable forest lands, already stocked with pulpwood species, are not available in quantity for purchase. Much of this land is held by large private owners who hold them for recreational purposes primarily, and of course, over 2,000,000 acres in the Adirondacks and Catskills are owned by the State of New York. Second, the present method in this State of taxing forest land with the tax rate applied to the valuation of the land and timber together year after year, makes the cost of holding timberlands and growing wood very costly. Many companies, which formerly held sizable woodlands, have disposed of them for this reason. Therefore, the possibility of the industry's increasing its acreage through additional purchases of timbered lands cannot be carried very far.

Industry, however, should look further into the planting of suitable species of trees to augment future pulpwood supplies. There are large areas of abandoned farm lands in

G. A. Pesez, Asst. Resident Manager of Woodlands, International Paper Co., Glens Falls, N. Y.



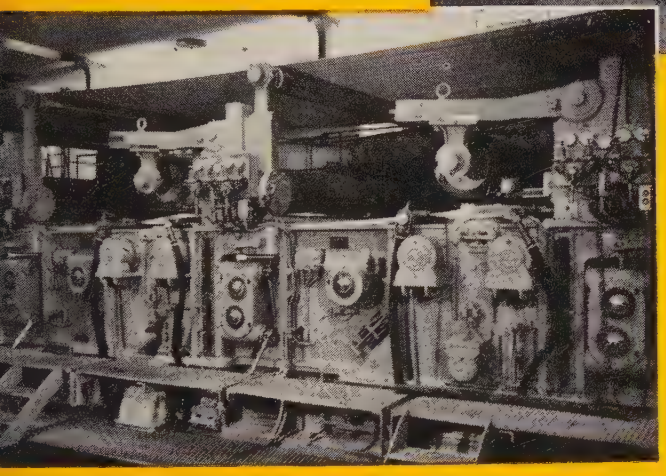


VEDEN LEADS THE WAY

e, aerial view of the mill of A. B. Papyrus, dal, Sweden.

v and right, close-up views of the new Cylinder ine with Stream-Flow Wet End which started y successful operation in October 1950.

forming part of the new machine at Papyrus sts of four Vacuum Stream-Flow Vat Systems vacuum cylinder molds, 48" dia. x 120" face, Spreaders, Up-Flow Head Boxes, etc. A. B. rus have a total of 13 paper and board ma- s in operation, making a tremendous variety oducts, all of the highest quality.



uropean Papermakers turn to

Stream-Flow Vat Systems

A new cylinder board machine with a forming part consisting of four Goldsmith Vacuum Stream-Flow Vat Systems started up in the mill of A. B. Papyrus, Molndal, Sweden, in October 1950. This machine makes the highest quality European type folding boxboards from sulphite and groundwood pulps with an MG finish produced by a Yankee Dryer. It makes a wide range of sheet weights, namely in caliper from .014 to .050.

This is the second highly successful new machine to start operating in Sweden with Vacuum Stream-Flow Vat Systems during 1950. Stream-Flow Vat Systems are now also on the drawing boards for machines to be installed in France and in England.

When Papyrus selected Stream-Flow Vat Systems as the forming part of their new machine, their choice was based on a wide experience. Their satisfaction with the performance of this new machine is a just reward for their decision not to be content with second-best equipment.

Whatever your product may be — test liner, corrugating board, folding boxboards, high-grade boards or cylinder papers, felt or special products — Puseyjones Stream-Flow Wet End on your new or rebuilt machine will give you the assurance of better sheet quality, higher speed possibilities and furnish economies.

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New York State ideally suitable to reforestation. While the bulk of this land is not tributary to many of the mills, there are areas within easy trucking distance of the mills. Species such as Norway pine, white spruce, Norway spruce, and European larch make excellent growth when properly planted and thinned.

How fast do planted trees of the above species grow? To give you some basis of comparison, some of the southern pines, notably loblolly and slash pine, grow at the rate of 1 to 2 cords per acre per year on good sites. In the Adirondacks on lands cut over by pulp and paper companies, leaving a fair growing stock per acre, the rate of growth has been estimated to be between $^1/_4$ and $^1/_2$ cord per acre per year. Norway pine, grown on good sites, has been known to average 1 cord per acre per year for the first 30 to 40 years at which age it is ready to be harvested for pulpwood. This rate is an average from the seedling stage, so that for several years the rate of growth per acre per year is considerably in excess of 1 cord per acre per year. Norway spruce does exceptionally well also when not retarded by white pine weevil. Its rate of growth on good sites approximates three quarters of a cord per acre per year. White spruce does as well as Norway spruce, and is not so susceptible to attack by the white pine weevil. European and Japanese larch, as well as hybrid species of these larches, make very rapid growth, in excess of that made by red pine, averaging $1^1/_2$ cords per acre per year. However, to date the larches have been found suitable for the sulphite process only.

So far we have discussed principally the softwoods or long-fibered woods which most of the mills still rely upon and which are becoming scarcer through overcutting. It is in the use of these species also that the pulp and paper industry has the most competition from other industries, principally the sawmills. While the pulp and paper industry can utilize trees of less than saw-timber size, it is not very economical to do so, and today about 60% of the softwood pulpwood cut in New York State comes from trees of saw-timber size. With current prices for lumber what they are, the competition for available softwood stumpage of saw log size is very keen and the pulp and paper industry is usually at a disadvantage in bidding on such stumpage.

Turning from softwoods to the hardwoods, we find we have in our State today more than 3 cords of hardwood for every cord of softwood. Unlike softwoods, hardwood pulpwood is generally cut from trees of lower than saw-timber size and quality. There are several reasons for this—first, the value of hardwood stumpage of saw-log size is generally much higher than that of softwood stumpage of saw-log size. Second, hardwood is so heavy that it is impractical to attempt to handle it manually in 4-foot bolts of diameters exceeding 15 inches.

With such a preponderant backlog of hardwood as against softwoods, it would appear that New York's pulp industry will be obliged to turn more strongly to hardwoods. Several mills already are utilizing various species of hardwoods in increasing quantities.

Recent figures released by the Northeast Forest Experiment Station reveal that our 11 million acres of commercial forest lands are growing hardwood at the rate of 4.7 million cords annually, of which 2.6 million cords are in trees of saw-timber size and 2.1 million cords are in pole-timber or pulpwood size trees. The annual growth of hardwood in trees of pulpwood size is therefore about twice the annual consumption of pulpwood of all species by the mills of New York State for this year. Only 50 to 75,000 cords of hardwood will be used by the New York mills in 1951, or $3^1/_2$% of the annual growth.

There are, of course, many reasons why hardwood has not, to date, been used extensively for pulping. First and foremost is that heretofore the long-fibered species, spruce and fir, have been in fairly good supply and they are much easier to pulp. Second, plant conversion for the use of hardwood is very costly; third, hardwood pulp is heavy to handle and is not so readily sap-peeled as the softwoods, and the peeling season for hardwoods is one half as long as for softwoods. Many mills do not have debarking equipment, and therefore require all of their wood to be peeled in the woods which further restricts their use of hardwoods.

However, with the advent of mechanical saws, tractor skidding, mechanical loaders, and last but not least chemical debarking of trees, the hardwoods will be relied upon more and more as a source of raw material for pulping. Perhaps some of you have not heard about chemical debarking. It consists of girdling trees in the growing season, applying a chemical to the girdle, which kills the trees and also induces bark separation from the wood. Different varieties of trees respond in varying degree to this treatment, but experiments, to date, show great promise. Industry in the Northeast thinks so well of this method of debarking trees, that ten companies have joined with the New York State College of Forestry at Syracuse to set up a foundation to conduct a research program in chemical debarking. Fifty thousand dollars have been pledged by ten companies to carry on this research for the first year. In passing, it is encouraging to state that, so far, indications are that this treatment works especially well on hard maple and beech, two varieties that do not sap-peel readily. Beech, in addition has not been used very extensively by either sawmills or pulp mills, and as a result there is a great deal of beech in our woods today.

To further stretch out our supply of pulpwood, the industry is utilizing some by-products of other wood-using industries, notably cores of various veneer plants. However, there is a great source of sawmill waste in the form of slabs that could and should be utilized by the pulp industry. The chief objection to wider use of slabs is that of bark removal. Slabs do not lend themselves to drum or stream barking for bark separation. Some attempts are being made to have the sawmills remove the bark from their logs before sawing. This, of course, can only be done readily during the sap-peeling season, and with logs cut in that season. If this could be achieved, the slabs from such peeled logs would be bark-free and readily usable to the pulp mills. On the West Coast this has been done extensively.

The use of portable chippers that go into the woods and convert practically the entire tree into chips, is being tried out in some areas. Here again bark separation is a major problem, but it does make for almost complete utilization of a tree. To date, the product of these portable chippers has been confined to the manufacture of coarse board.

Another source of wood supply that is expected to become more and more important within a few years is the reforestation areas of the State of New York that are outside the Adirondack and Catskill Preserves and which form a part of our commercial forest area. Beginning about 1930, New York State has planted over 285,000,000 trees of assorted species on 236,528 acres. Red pine, white pine, Norway spruce, and white spruce form the bulk of the plantings. From these areas, it is estimated that by 1960 around a quarter of a million cords may be cut, and thereafter annually 50 to 75,000 cords. By 1960 the State will have a growing stock of over 1,000,000 cords of planted trees.

Finally, industry is everready in New York State to cooperate with the Conservation Department in forest fire prevention and control and in the fight against injurious forest insects and disease.

In the disastrous windstorm of Nov. 25, 1950, industrial and State forests suffered severe damage. Although several of the large industrial landowners had sufficient wind-thrown timber on their own lands to engage all of their logging facilities, industry responded well to the State's offer to bid on damaged State timber. Pulp and paper companies have successfully bid on and are cutting approximately 90,000

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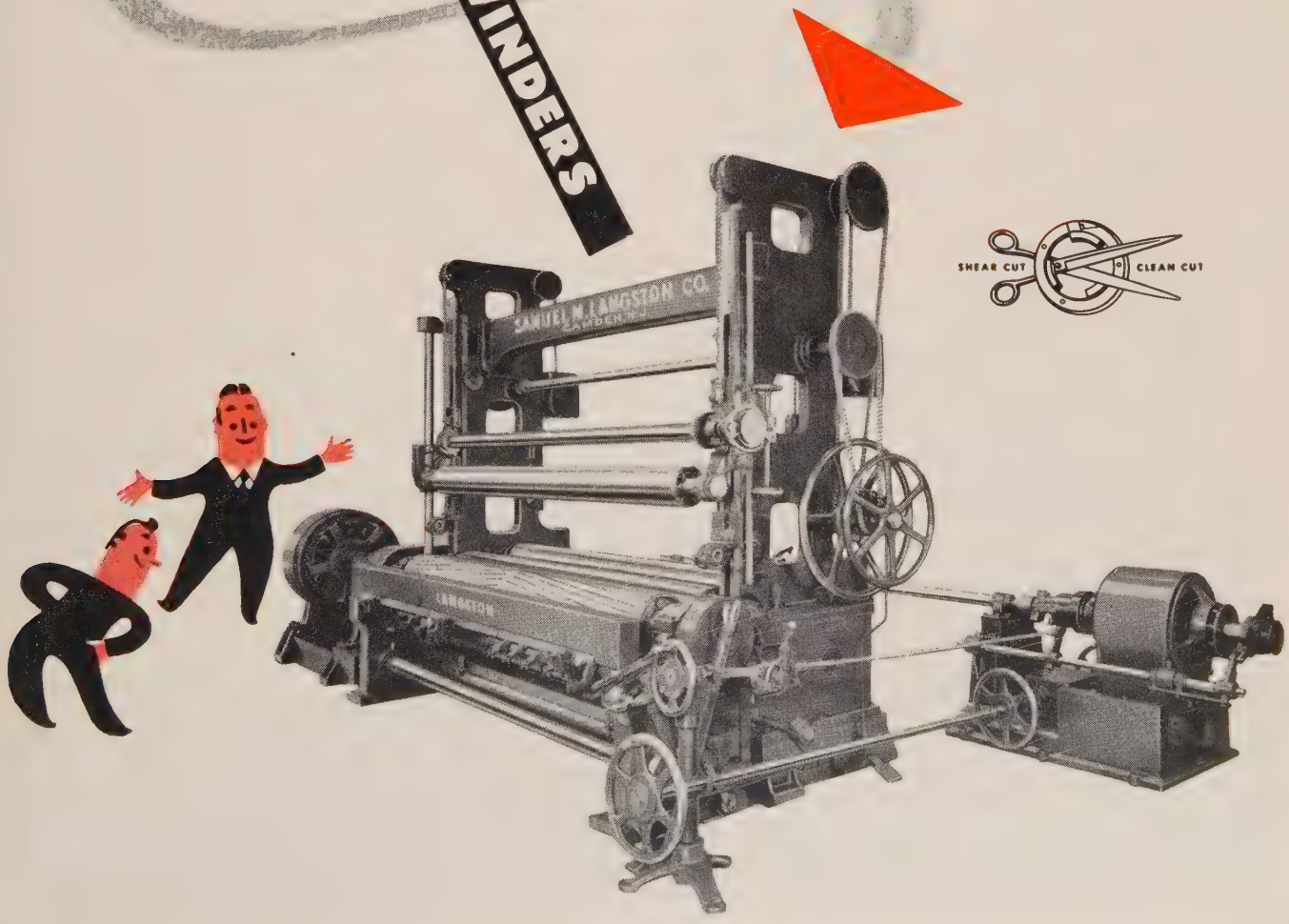

cords of storm-felled pulpwood on State lands this year. If additional manpower for woods work were available, considerably more of this damaged State timber would have been harvested at present. The logging crews occupied in salvaging this storm-felled timber, equipped with ample forest-fighting equipment, form the first line of defense in the event of forest fires.

The pulpwood industry should adopt a policy of growing a more substantial quantity of the pulpwood that it consumes, first by intensifying the forest practices on the lands it now owns, and second, by acquiring additional lands to increase total forest holdings to a level somewhere between 1 and $1^1/_2$ million acres, the balance of the wood supply might be obtained from lands not company-owned and from State reforestation areas.

This combination of effort should go far to reduce our growing dependency on outside sources for our pulpwood supply.

Public and Private Forestry Get Together

J. VICTOR SKIFF

It is a pleasure for me, as a representative of your Conservation Department, to take part in this meeting built around the important theme "The Future of the Paper Industry of New York State."

I am not prepared to make a technical contribution to your conference, but I am glad to say a few words in regard to the forest policy which we have been developing and some of the steps we have taken to make it effective.

At the beginning of the present administration, as a first step, the existing forestry program was carefully scrutinized in relation to the forestry needs of our State. We discovered that up to that time while New York had been a pioneer in state reforestation, had a fine record for forest fire control, had done outstanding work in forest pest control, and had a well-developed program of forest recreation, the big missing link seemed to be the development of some kind of cooperative effort between forest owners and the State which would make the woodlands of this State more productive.

We recognized and accepted four important facts which are elementary to the men of your industry:

1. We are fortunately situated in this State in having a tremendous industrial capacity—and there is no better example of this than the paper industry.
2. We have $13^1/_2$ millions of acres in some kind of forest growth.
3. The annual production per acre in these enormous forest lands is ridiculously low, perhaps something around one quarter of a cord per acre.
4. Despite this vast outdoor factory for the production of timber, we are obliged to import 70% of the lumber and 58% of the pulpwood that are consumed here.

The problem, then, was to try to shape a policy and a program which would stimulate the production of more timber, and better timber, on the extensive forest lands of our State. Moreover, it was obvious that the techniques of forest management had already been developed far enough so that the means of achieving greater production and better production were available, if some way could be found to apply them on a wide scale. In other words, some way had to be found to aid and encourage private landowners to practice forest management more intensively.

At this point it became clear that legislative action would be required to help establish a new forest policy along these lines and to set up the necessary legal machinery within which effective cooperation could be carried out.

Many of you are aware of the outstanding public service rendered in this connection by Harold Ostertag, who at that time was Assemblyman from Wyoming County and chairman of the Joint Legislative Committee on Interstate Cooperation. This committee under Chairman Ostertag's able leadership was able to bring together all the parties at interest, including representatives of the industry, our own department, and other agencies who worked in cooperation to secure the enactment of what is now our Forest Practice Act. I presume that you are all more or less familar with its provisions.

In the simplest possible terms, it sets up the machinery to provide for the establishment of definite standards for the practice of forestry on privately owned woodlands in the State, and for assistance from the State Conservation Department in carrying out these practices. The forest practice standards are set up by District Forest Practice Boards consisting of three members from each county in the district, who are appointed by the chairman of the board of supervisors with the approval of the board of supervisors. It is the duty of these boards to set up forest practice standards applicable to the various forest types in the district and to promote their application.

The District Forest Practice Board is composed of three members of each county, at least two of whom must be owners of forest land within the county. The third member may be a supervisor. In counties having soil conservation districts, the chairman of such a district is designated by the law as an *ex-officio* member of the District Forest Practice Board.

The activities of the District Forest Practice Boards are coordinated through a State Forest Practice Board composed of representatives elected by the various district boards. In addition, several *ex-officio* members are designated by the law. These are: the dean of the New York State College of Forestry, the dean of the New York State College of Agriculture, and the chairman of the New York State Conference Board of Farm Organizations.

One of the significant things about this act is the fact that it operates on the democratic cooperative plan rather than that of mandatory governmental regulation. While there are those who still insist that the State or the Federal Government should crack the whip over private forest landowners and tell them just what, how, and when they shall cut their timber, we in the department, on the basis of the wonderful progress which has already been made, sincerely believe that the policy under which we are operating will be far more successful in the long run. We believe that the development of Forest Practice Standards by districts, with due regard to the uses for which the forest products are to be put which as you know vary greatly from place to place, is the only way that forest management can be achieved.

Along the development and enactment of the Forest Practice Act, and in order to place the department in position to carry out the new policy and its new obligations, the field force of our Division of Lands and Forests was completely reorganized. We discovered that we had various kinds of forestry districts—for reforestation, for firefighting, for insect pest control—the boundaries in which in no case coincided. There was no central authority in each area for carrying out the work of the division, and so there was written into the new act provision for definite forest districts and our field force was completely reorganized into these districts each one of which is now administered by a professionally trained district forester. This streamlined and decentralized type of organization has proved most effective and has enabled us to deal not only with the new forest service problems but to better handle our older problems.

Of course, in order to bring this additional service to our forest landowners we have had to greatly expand our force of professional foresters. We now have over three times as many as we did when this new program and this new policy went into effect. I have spoken at some length about this

J. Victor Skiff, Deputy Commissioner, New York State Conservation Dept., Albany, N. Y.

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new Forest Practice Act and our operations under it, because while I am primarily interested here in outlining our policy to you, I don't know of any better test than can be put on a policy, or any better way that it can be illustrated, than by the specific actions which have been taken to carry it out. Actions speak louder than words.

Our policy, then, can be summarized as follows: to bring public and private forestry together in the closest and most effective type of teamwork with the State serving in its highest role as a service agency, bringing the type of advice and assistance to private forest landowners which it is difficult and, in many cases impossible for them to provide for themselves. We now believe that this policy is pretty well supported by the services which we are now rendering. First, in the matter of reforestation through our State nurseries, second, in the matter of fire control through our ranger force, third, in the matter of protection from forest pests, and finally in the important field of technical forestry service to our forest landowners.

While the Forest Practice Act is new, we believe most satisfactory progress has been made. Already, approximately one tenth of the private lands in this State are signed up under the terms of this act which means that these lands are being brought under improved forest management. That this will mean a greater yield of all kinds of forest products, including pulpwood, I am sure is incontrovertible. The responses of the industry itself to this program attest the same thing.

In closing, I want to say that this new effort on the part of our department to give greater service to the public of our State has brought many satisfactions to Commissioner Duryea and all the rest of us who have had a part in it. We are especially grateful for the friendly cooperation we have had from the industry. We realize that many of our forestry problems, including our production problems, are far from solved. But we do believe we are on the right track and we believe that with the same kind of teamwork we have enjoyed thus far that we can look to the future with confidence.

I also want to leave with you a cordial invitation to visit us at the Conservation Department whenever you happen to be in Albany and to send us any suggestions or constructive criticisms which you may have. They will be gratefully received and will get full consideration.

We Have Pulpwood in New York State

F. W. O'NEIL

The tremendous growth of the paper industry in this country in the last 15 years and the resultant forest cutting that is far in excess of the rate of growth, are rapidly depleting the available supply of the coniferous or softwood species in the United States. Prior to this period, the same type of timber cutting resulted in the serious depletion of New York State's coniferous forests. However, certain of these areas still support forest stands and if they are properly managed, a continuing supply of pulpwood should be available. New York State is exceedingly fortunate in having an abundant supply of water and power available for the manufacture of pulp, paper, and paperboard, and the proximity of all areas to large markets is unsurpassed in the United States. Why then has the wood pulp production in this State decreased during the past several decades? In 1911 New York State produced 24% of the total pulpwood cut whereas in 1927 only 6.1% was cut in this state. By 1914 New York State had lost the lead in wood pulp production to Maine, and since that time Wisconsin, Washington, and Louisiana have also forged ahead. The state, has, however, retained its leadership in the production of paper and paperboard, not because of the supply of pulp produced within the State but because of the productive capacity of the established mills supplied by the importation of pulpwood equivalent to 375,000 tons of pulp, 482,000 tons of wood pulp, and the utilization of 874,000 tons of waste paper and nonwood pulp (*3*). This is pictorially represented in Fig. 1.

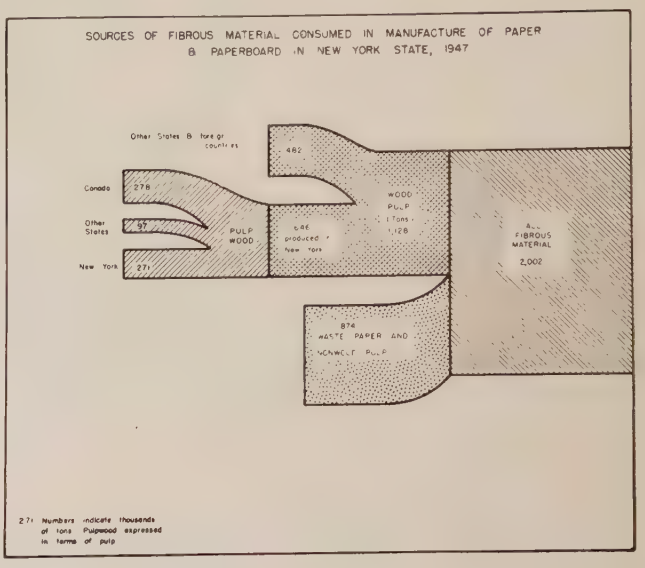


Fig. 1

The wood used in the manufacture of pulp in New York State mills in 1947 amounted to 884,000 cords, of which 43% came from Canada, 15% from neighboring states, and 42% from within the state. In addition to the importation of 58% of its pulpwood, New York State also imports large quantities of pulp having a pulpwood equivalent of 665,000 cords or 178% of its own production. The total pulpwood production of New York State amounts to only 370,000 cords and in the manufacture of paper and paperboard, the industry consumes 1,549,00 cords (Fig. 2). An accurate

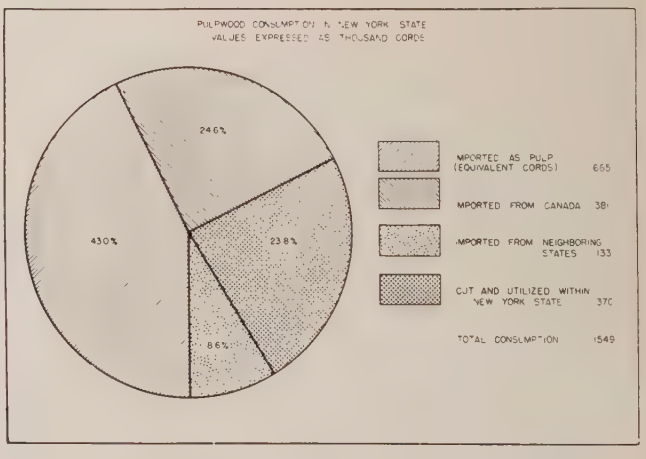
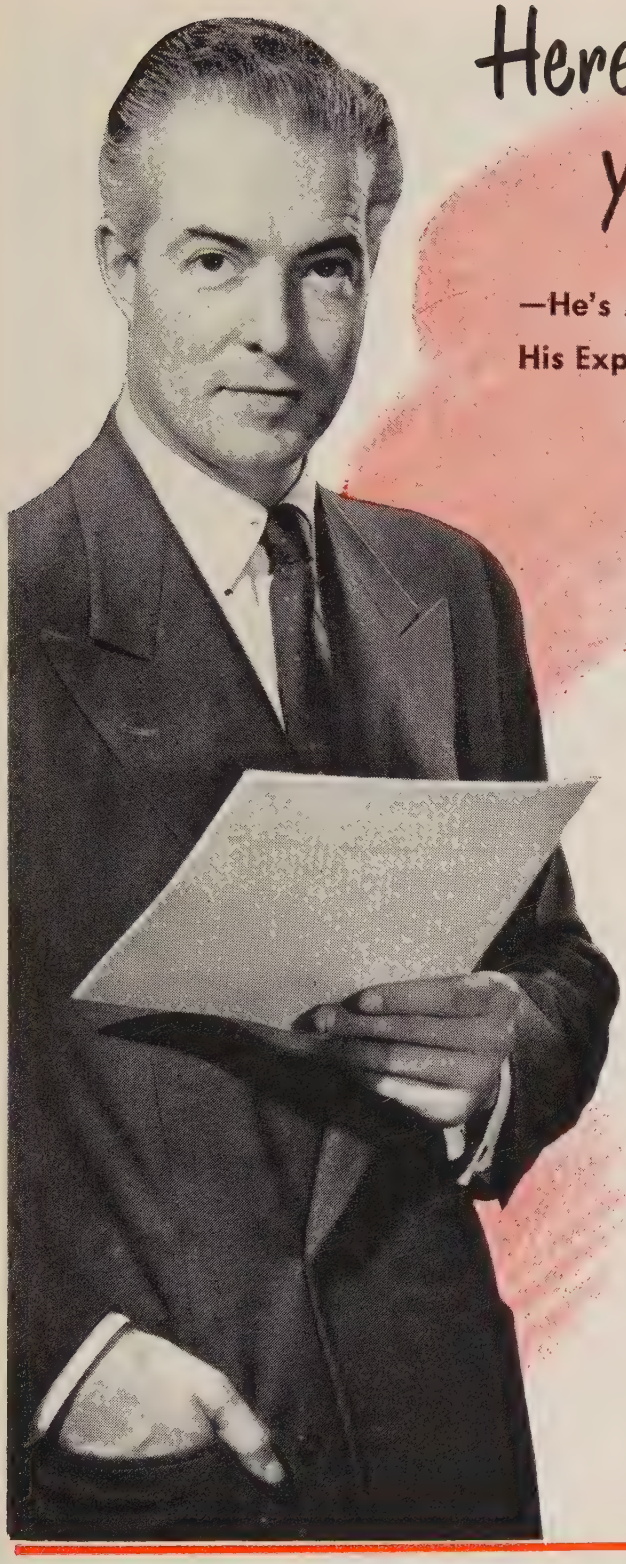


Fig. 2

appraisal of the wood supply in this State cannot be made at the present time since only 30% of the field-work of the forest survey being conducted by the Department of Agriculture, Forest Service, has been completed. However, a report of the Division of Lands and Forests, Conservation Department,

F. W. O'Neil, Associate Professor, Pulp and Paper Manufacture, State College of Forestry, Syracuse, N. Y.



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New York State, for 1949, contains the following information:

Present forested area, acres	13,500,000
Idle or unproductive forest area, acres	4,000,000
Present old growth timber area, acres	100,000
Present timber stand, board feet	25,279,000
Per cent hardwoods	72
Per cent softwoods	28

According to additional data compiled by the Northeastern Experiment Station for New York State and New England, the manufacture of products from wood has an annual requirement of 13 million cords. Forest insects and diseases and fire account for an additional 2 million cords, resulting in a total drain of approximately 15 million cords annually (*2*).

Table I. Timber Volume[a] in New England and New York, Status Beginning of 1945 (Million Cords) (*4*)

Softwoods		*Hardwoods*	
Spruce and fir	103	Birch, beech, and maple	248
White and Norway pine	40	Oak	30
Hemlock	28	Aspen	17
Other	7	Other	20
Total	178	Total	315

[a] Trees 5 inches diameter breast high and larger; does not include bark. Converting factors: softwood, 1 cord equals 78 cu. ft.; hardwoods, 1 cord equals 65 cu. ft.

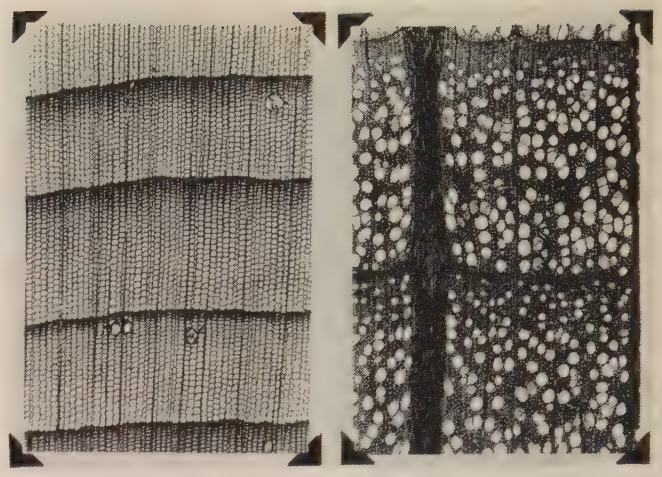
Of this total volume, 42% or 5.7 million cords are softwoods and 58% or 8 million cords are hardwoods. The excess of growth over drain (4 million cords) prevalent in the hardwood supply is very significant since the bulk of these hardwood species consists of beech, birch, maple, and aspen. Inasmuch as the hardwoods are available and, because of past cutting practices, are forming the prevalent species, it appears logical to assume that a forward looking industry, interested in protecting its investment, would undertake steps to determine how to utilize these woods to their best advantage. A comparison of these values indicates that a higher percentage of hardwoods is available in New York State than in the New England area.

Table II. Comparison of Annual Drain and Growth, Status Beginning of 1945 (Thousand Cords) (*4*)

Item	*Drain*	*Growth[a]*	*Surplus*
Softwoods	5,754	6,449	695
Hardwoods	8,040	12,092	4052
Total	13,794	18,541	4747

[a] Annual growth of all trees 5 inches diameter breast high and larger, including tops and limbs (tops only in softwoods) of saw-timber and total volume of trees reaching 5 inches diameter breast high each year. Bark not included.

Undoubtedly, if a group of eastern papermakers was asked what tree produced the best fiber for papermaking, the majority would answer "spruce." Suppose, however, Zenias Crane had been asked to make paper from spruce fibers when he first started his mill in Dalton, Mass. He probably would have said that it was impossible. Well, it has been accomplished. Now the question arises—can we make satisfactory papers from hardwood pulps, equal in quality to those produced from spruce? I believe that this can be accomplished for the step from rags to spruce was much greater than the one from conifers to hardwoods.



Spruce Beech

Fig. 3. Cross section of spruce and beech

An inspection of the physical characteristics of the various fibrous elements of the hardwoods and spruce will indicate vast differences (Table III). However, application of "know-how" can certainly circumvent many of these differences and by developing specific techniques very satisfactory pulps could be obtained. It may be advisable at this point to explain certain outstanding differences between the hardwoods of the northeastern United States and a common softwood, i.e., spruce. In general, hardwoods are considered to be those species having broad leaves which are shed each year, and softwoods (conifers) are those which have narrow leaves (needles) and retain them for several years. The name does not refer to the hardness or softness of the wood itself. The two types can also be differentiated microscopically. Figure 3 shows cross sections of spruce and beech and Fig. 4 shows tangential sections of these species. The tracheids (fibers) occupy about 93% of the total volume of spruce whereas the total volume of the hardwoods is divided approximately into 21% vessel segments, 66% fibers, and 11% ray cells.

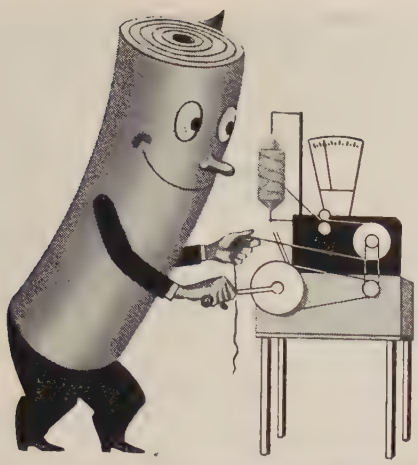
Other characteristics which must be considered are the tremendous differences in fiber length and in the cell wall thickness. These morphological differences govern within certain limits the ability of liquor to penetrate the wood and the magnitude of the average strength of the pulps and papers obtained from these woods. For instance, the large-diameter vessel segments are ideal canals for the rapid penetration of treating liquors into the chips; this factor should be considered when determining the cooking schedule. The thickness of the cell wall governs the stiffness or the flexibility o

Table III. Physical Characteristics of Some Woody Tissues (*1*, *2*)

Species	*Length, mm.*		*Fibers, wall thickness*	*Vessels per sq. mm.*	*Volume, %*			*Density,[a] lb./cu. ft.*
	Fiber	*Vessels*			*Fiber*	*Vessel*	*Rays*	
Spruce (*Picea glauca* Voss)	3.1–3.3[a]	...	Thin	...	93[b]	..	6	25.0
Aspen (*Populus tremuloides* L.)	0.74–1.3	1.45–0.71	Thin	30–120	53	33	14	22.6
Birch (*Betula lutia* Michx)	1.15–1.4	0.74–1.18	Thin	60–160	66	21	11	35.5
Beech (*Fagus grandifolia* Ehrh)	1.07–1.42	0.51–0.66	Thick (small diam.)	50–200	..	..	20	35.0
Maple (*Acer saccharum* Marsh)	0.71–0.78	0.30–0.34	Thin	40.90	61	21	18	35.6

[a] Oven-dry weight
Wet volume
[b] Tracheids

the fibrous element. The thinner the cell wall, the better the felting properties of the fiber and consequently a stronger mat of fibers will result. The fiber length is of course the most significant difference between the hardwoods and soft-



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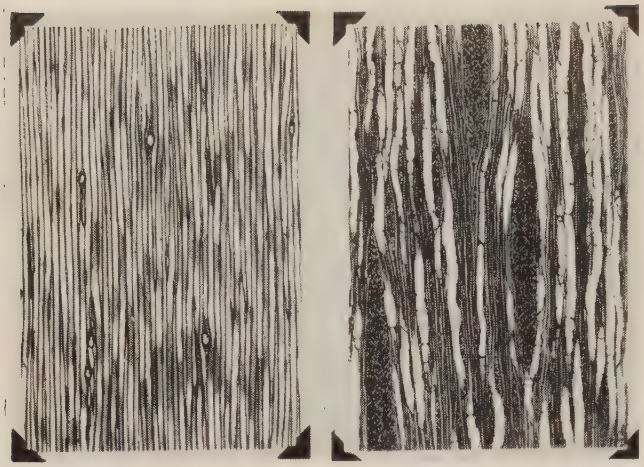

Spruce Beech

Fig. 4. Tangential section of spruce and beech

woods and since the average hardwood has fiber lengths of less than one half that of spruce, a somewhat lower tearing strength may result. Especial significance should, in the face of increasing wood costs, be attached to the high densities of beech, birch, and maple. Approximately 40% more wood per cord is available from these dense hardwoods than from spruce.

The hardwoods and softwoods also differ in chemical composition (Table IV). The cellulose content of aspen is exceptionally high and will tend to increase the pulp yield from chemical digestions. This factor will tend to make up for the relatively low density of this species. The more dense hardwoods have equal or slightly lower cellulose content than spruce, and the yield per cord will be considerably greater. The lignin content of the hardwoods is considerably lower than the value obtained for spruce whereas the pentosan content should require less drastic digestion schedules particularly when consideration is also given to the presence of the large diameter vessel segments present in these woods. The high pentosan content of the woods would prove disadvantageous in the manufacture of dissolving pulps by alkaline process. However, a prehydrolysis treatment followed by a mild alkaline digestion, will lower the pentosans to a value acceptable for dissolving pulps. If a standard papermaking pulp is desired, an alkaline digestion liquor similar to regular sulphate is all that is necessary. The high density, low lignin content, and the presence of pentosans make these hardwoods especially suitable for processing by high yield methods.

The literature abounds with information pertaining to the application of the various pulping processes to hardwoods, and several of the hardwoods have been used for the manufacture of filler pulps by the soda and the sulphite process. However, probably governed by past history, the inherent properties of these pulps were never developed. They were

Table IV. Chemical Characteristics of Some Woods. Basis O.D. Wood (9)

Species	*Cross and Bevan cellulose, % by weight*	*Lignin by sulphuric acid, %*	*Pentosan, %*
Spruce (*Picea glauca* Voss)	61.2	26.6	10.39
Aspen (*Populus tremuloides* L.)	64.1	17.3	...
Birch (*Betula lutia* Michx)	61.3	...	24.6
Beech (*Fagus grandifolia* Ehrh)	58.8	...	...
Maple (*Acer saccharum* Marsh)	57.9	23.5	21.7

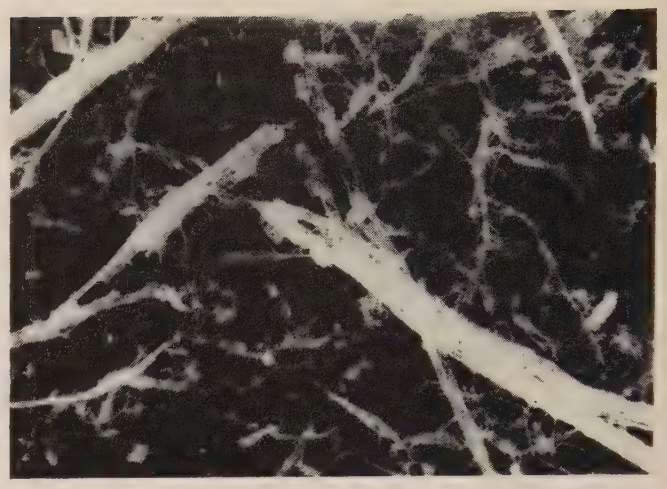

Fig. 5. Commercial spruce groundwood

doomed because of their known short fiber length to play an inferior role in the manufacture of quality papers. Necessity has, however, brought about a significant change in these thoughts, especially in Germany and Sweden. G. Jayme and co-workers have reported considerable progress in the manufacture of pulps from beech. Commercial Scandinavian pulps of high strength manufactured from birch and aspen are now being used in the United States.

European beech (*Fagus sylvatica*) has been used in Germany as a raw material for chemical pulps for many years. Jayme (*7*) has investigated various digestion techniques and produce pulps having widely different properties. By digesting birch at 170°C. for 5.5 hours with caustic soda or caustic soda and sodium sulphide, yields of 48% were obtained. These pulps have high pentosan content, bleach easily to high brightness values, and are capable of developing satisfactory strength characteristics. If a pulp of low pentosan content is desired, a prehydrolysis treatment of the chips with sulphuric acid prior to alkaline digestion will produce low pentosan content pulps of yields between 32 to 34% and pentosan contents of less than 5%. The high alpha-cellulose content (92%) combined with the low pentosan fraction makes these pulps suitable for artificial silk and cellulose wool production. Furfural in amounts of approximately 450 pounds per ton of pulp, a yield of better than 20%, has been obtained from the prehydrolysis liquors.

Processing hardwoods with sulphite cooking liquors has of course been practiced for many years and pulps suitable for book grades have been produced. The digestion techniques, however, have been an adaptation of those used for pulping coniferous pulps. G. Jayme and E. Lochmiller-Kuhn (*6*) have taken into consideration the morphological charac-

Fig. 6. Beech chemigroundwood

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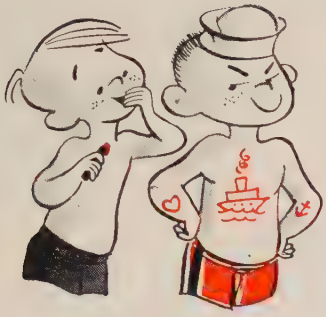

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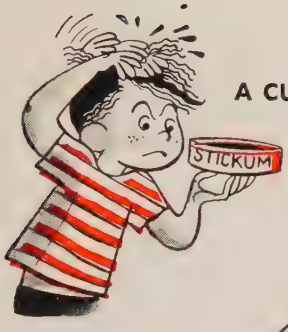

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teristics of beech and have developed a special pulping procedure using smaller sized chips and consisting of pre-evacuation, high liquor concentrations, higher temperatures, and short digestion time. Pulp yields of 46% are possible and when bleached the pulps are suitable for the production of viscose synthetic fibers.

The production of high yield pulps from beech has also been investigated by G. Jayme and co-workers (*5*). Unbleached pulps in yields of 70% have been produced and when bleached the pulps are reported to have strengths equal to pulps produced by conventional methods. The bleaching results in a marked increase in the pulp strength with only a slight reduction in yield to 62.5%.

We are all familiar with the excellent work of the Forest Products Laboratory, Madison, Wis. They have pioneered in the development of the semichemical process for the production of high yield pulps from hardwoods using a neutral sulphite liquor. Most of the results of their investigations are available in the literature or in their special reports.

The Empire State Paper Research Association, Inc., in conjunction with the State University of New York College of Forestry also has investigated the pulping of hardwoods by the semichemical process and obtained excellent results. Liquors of various compositions have been utilized in this phase of the investigation including soda, sulphate, sodium sulphite, bisulphite liquors, and others.

Pulp yields ranging between 70 and 90% are possible and this high yield combined with the high density of these woods, results in excellent yields of pulp per cord, i.e., between 2200 and 2800 pounds. Bursting strengths of 0.60 point per pound and tearing strengths of 1.1 grams per pound at 350 in freeness are possible from beech pulps.

The chips produced by this process can be treated in a disk refiner for use in grades ranging from board to book and glassine.

When the semichemical pulps in the range of 70 to 75% yield are bleached, the resulting fibers have excellent papermaking properties, and the bleach requirement for these pulps is generally less than 18% chlorine when using multistage bleaching techniques. This bleaching process is essentially a continuation of the purification process and increased pulp strengths are obtained.

Another phase of the research work carried out at the college has been the development of a pulping process for the manufacture of a high yield mechanical pulp from hardwoods. This pulp, known as "Chemigroundwood" (*8*) is produced from hardwoods by grinding on a conventional wood pulp grinder after first treating the billets under pressure in a digester. Test data from pulps produced from beech, birch, and maple have indicated that certain economic advantages can be obtained by utilizing this process. Chemigroundwood pulps yielding approximately 25% more pulp per cord of wood than obtained from spruce can be produced from these dense hardwoods. The power requirements of these pulps are about 60% of that required for spruce, and they can be manufactured at a rate of 2 to 4 tons per square foot per day (125 to 300% of the rate for spruce on a similar grinder). In addition to these advantages, the pulps are much stronger in bursting and tearing strength than spruce mechanical pulps. Chemigroundwood pulps can be refined in a disk refiner for higher strengths and are readily bleached to 70 to 75 brightness units with peroxides or hypochlorites. The characteristics of these fibers are best brought out by a comparison of photomicrographs (Fig. 5) of spruce mechanical pulp and beech mechanical pulp (Fig. 6) which shows the excellent long individual fibers obtainable from these hardwoods without sacrifice of power requirements, production rate, or yield.

References have tended to stress the application of the various processes to beech. However, the techniques followed should also be applicable to the other hardwoods. Beech is intermediate in fiber length to birch and maple, of about the same density, and generally has thicker fiber walls.

Aspen of course is a much less dense and softer wood. Excellent pulps have been made from it by the neutral sulphite semichemical process.

Many mills have been producing satisfactory mechanical pulps from this species for years. Aspen, when treated by the Chemigroundwood process, produced pulps with yields of 87%, having bursting and tearing strengths of four times the values obtained from pulps manufactured from untreated aspen.

Hardwoods are with us. Let us supplement our dwindling coniferous reserve by using them intelligently.

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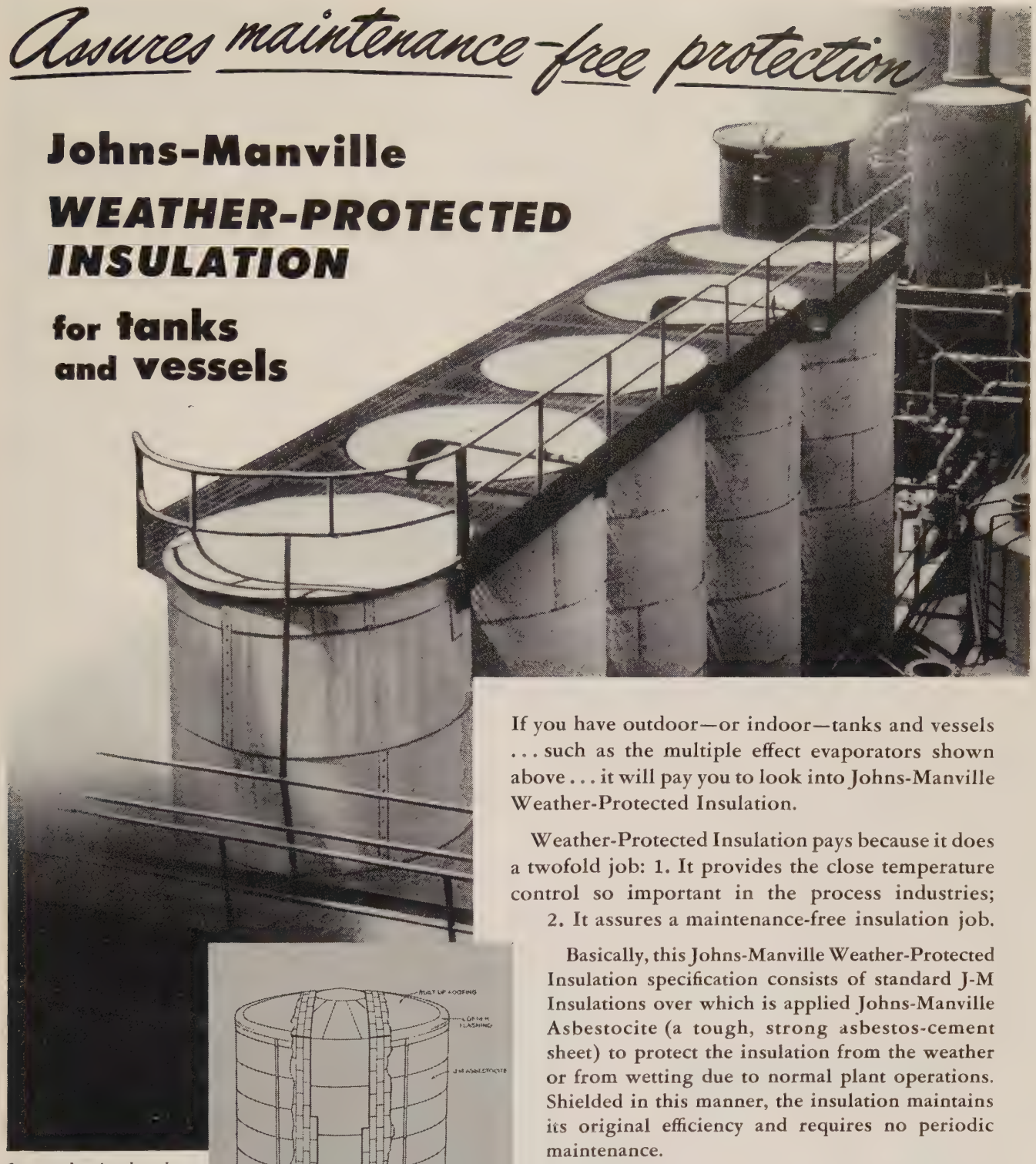

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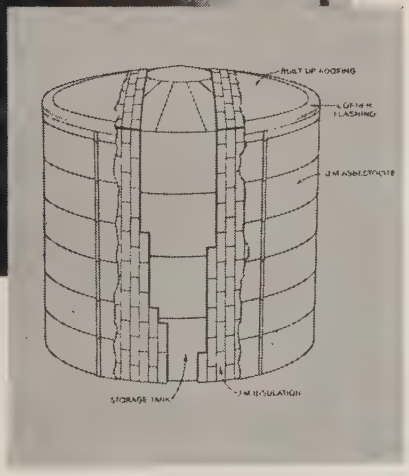

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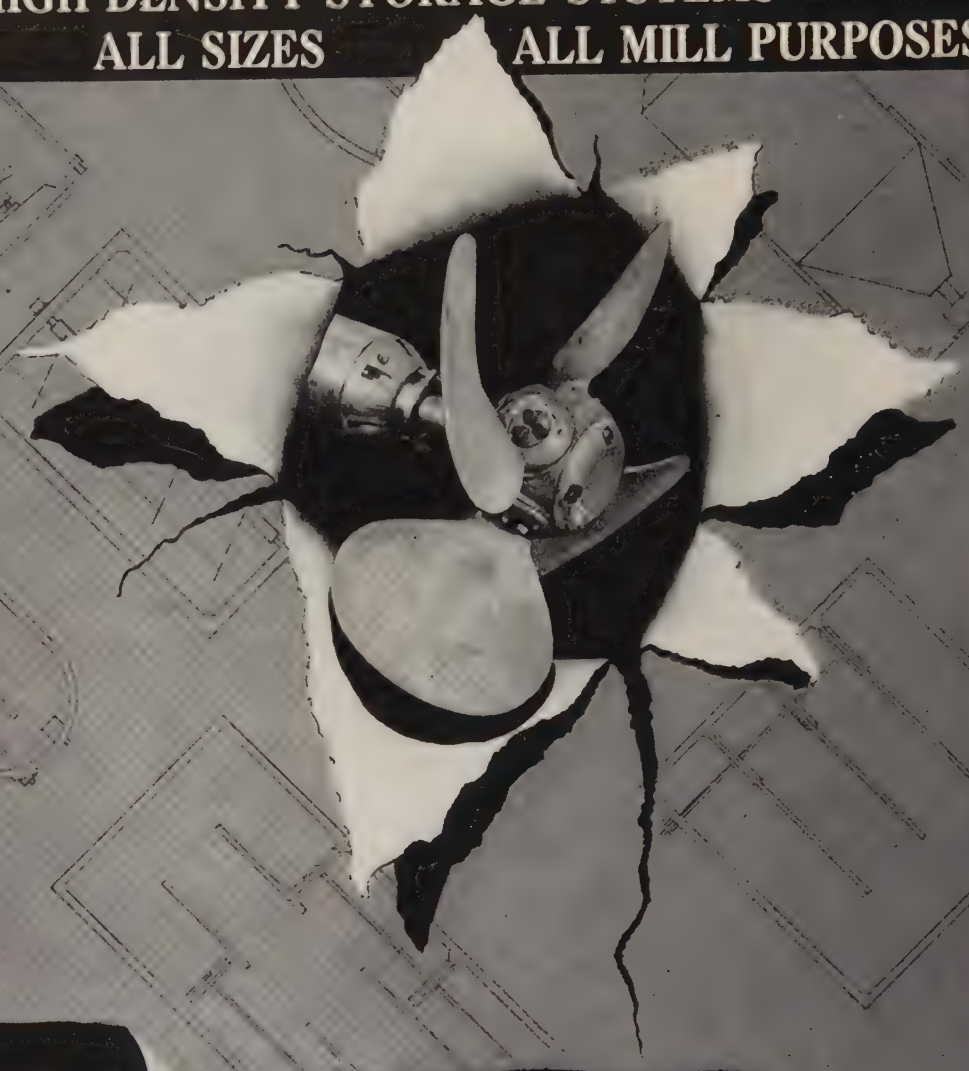

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Budgeting for the Research and Development Department

A. G. LURIE

One of the reasons for the eminent success of many American commercial enterprises, is the intelligent and effective use of forecasts, budgets, and budgetary control by management. Expenditures of vast sums of money for research, for development in the techniques of manufacture, and for the investigation of new products also contribute materially toward expansion and continued progress. The budgeting control principles used in effective management of the manufacture and sale of its products, can also be used by management in controlling the expenditures for research and development, to obtain the greatest advantage from these expenditures of money and effort.

The establishment of a research and development budget is a relatively simple matter. However, the preparation of such a budget for effective control is a more comprehensive procedure. The methods followed for both steps will be outlined herein.

Budgets for research and development can be established by several different methods, depending upon the viewpoint of top management. Suggested methods for establishing the amount of dollars to be expended during a given period, usually a year, can be based upon any one of the following considerations, or any combination that management may desire:

1. The amount of the budget may be established at a fixed percentage of the estimated sales for the ensuing period, or it may be based upon the sales for the past period.
2. It may be desirable to budget a percentage of net profits before taxes.
3. Management may decide to base the expenditure for the ensuing period upon the amount that had been spent during the previous period, modified either upward or downward by the change in volume of sales, the change in profits, or similar consideration.
4. The research budget may be dependent upon the operating budget, and the amount determined from the forecast of sales or budgeted profits before research and development.
5. A general review and study of economic conditions, future prospects, competition, etc., may influence the establishment of the budget.
6. The least scientific method of approaching this problem is to fix the amount by arbitrary determination.

Thus the amount of the budget for research and development is established and the first major premise for the budgetary control of a research and development department is provided. But merely establishing a budget, does not give the directors of the research department any guide for programming their efforts. Such guidance is invaluable for those who must make decisions, direct the orderly progress of the development program, and intelligently plan and control the work of the department.

The preparation of the budget is a twofold operation. It must first be prepared by classification of expenditures so as to enable the technical director and supervisors to provide for facilities and staff in accordance with the amount of money available (exhibit A). The second phase is the preparation of the budget of projects upon which the expenditures will be spent (exhibit B). In each instance the amount of dollars is the same, but the manner of expenditures is definitely outlined. The preparation of these budgets should be a joint project of the research department and the budget or accounting department to insure compliance with techniques established for the accounting of the expenditures. The first portion of the budget is relatively easy to prepare and can be fairly definitely fixed. The second portion must provide for changes throughout the period to prevent the technical director and his supervisory staff being hamstrung by inflexibility.

A. G. Lurie, R. S. Aries & Associates, Consulting Engineers & Economics, New York, N. Y.

BUDGET OF EXPENSE CLASSIFICATIONS

The budget by expenditure classifications could be fairly simple, but if a comprehensive budget is desired, can also be quite involved. The degree of complexity depends largely upon the size of the department, the amount of money involved, and the amount of information and control desired by those charged with the responsibility of managing the research department. A basic budget may consist of classification of expenditures such as:

1. Payrolls, consisting of all salaries and wages, together with all related costs, such as social security taxes, compensation insurance, group insurance, and similar related payments.
2. Supplies and materials, consisting of expendable equipment and operating supplies.
3. Other direct operating costs, originating within the department.

Such a setup, consisting of merely a few figures, can provide a fairly satisfactory budget, with budgetary control of the expenditures for a small or medium-sized department. A description of the elements entering into each of the above classifications will be developed in the more detailed budget as described hereinafter for each of the above major classifications.

The following is a suggested budget with classifications in detail for more effective control.

1. The subdivisions under payrolls, may be the following:

   A. Technical salaries representing professionally trained personnel.
   B. Nontechnical salaries and wages of such nonprofessional employees as laboratory technicians, draftsmen, etc.
   C. Service employees, such as stenographers, clerks, and clerical workers required by the department.
   D. Plant labor, consisting of hourly workers borrowed from operating departments for specific work as required, for which research department personnel is not available.

2. Supplies and materials consist of two major items. namely:

   A. Expendable equipment, of all nature that is purchased for specific projects or for general use in the research department but which does not become a part of the basic equipment.
   B. Supplies and materials, of any nature whatsoever.

3. Other direct costs can include, but need not be limited to the following:

   A. Books, periodicals, dues and subscriptions, and items of like nature required for the department staff or library.
   B. Travel expense of research department personnel.
   C. Fees for outside technical, engineering, and consulting services.
   D. Taxes, depreciation, and insurance on building, permanent fixtures, furniture, and equipment.
   E. Cost of service facilities from the plant, such as light, heat, power, steam, etc.
   F. Miscellaneous.

DETERMINATION OF BUDGETED AMOUNTS

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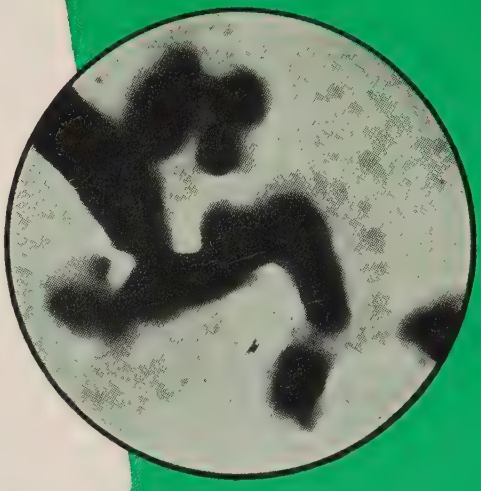

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Exhibit A

Research and Development Division Expense Budget—Year Ending December 31, 1951

1.	Payroll	
	A. Technical Salaries	$150,000
	B. Nontechnical salaries	30,000
	C. Service employees	20,000
	D. Plant labor	10,000
	Subtotal	$210,000
2.	Supplies and Materials	
	A. Expendable equipment	$ 24,000
	B. Operating supplies	15,000
	Subtotal	$ 40,000
3.	Other Direct Costs	
	A. Books, dues, subscriptions, etc	$ 5,000
	B. Travel expenses	15,000
	C. Technical, engineering, and consulting fees	15,000
	D. Taxes, insurance, depreciation	5,000
	E. Light, heat, power, etc	5,000
	F. Miscellaneous	5,000
	Subtotal	$ 50,000
Total budget		$300,000

mally is the salary and wages of those employed in the department. After determination of the personnel required, it is relatively simple to develop the dollars involved by totaling the sum of the salaries to be paid to the individuals who will be engaged in research work. To this amount should be added the social security taxes, pension payments, disability insurance payments, employee compensation insurance premiums, and the cost of other employee benefits. An estimate can be made of the plant labor required in the operation of the research and development department. Such a figure can be readily obtained from a study of previous experience.

The budget for supplies, materials, and expendable equipment can be based upon past experience, the size of the personnel for the ensuing budget period as compared with the personnel of the previous periods, and from the relative cost prices of these materials. Under present conditions, even though the quantity requirements might be the same as for the previous year, the cost would go up because of increased prices for this material.

Other direct costs can be readily determined from the various factors involved. Dues and subscriptions are relatively fixed. The books that are to be purchased for the library can be fairly readily determined based upon past experience. Travel expense depends upon several factors, such as the number and location of principal meetings of the technical societies, the locations of the plants of the organization, the area in which the customers are located, and the general policy with regards to travel expenses. Past experience can be a good guide in determining what the expenses might be in the future.

Technical, engineering, and consulting fees can be ascertained with relative degree of accuracy. A review of the projects contemplated during the period would indicate whether the staff can handle all problems involved. A review of the capabilities of the staff personnel and the contemplated changes therein must be considered in arriving at the amount of money that would be spent for outside assistance.

Taxes, insurance, depreciation, light, heat, and power and other similar expenses are usually fixed by the distribution of the total cost to the company and an amount allocated to the research and development department. The amount would therefore be obtained from the budget of the operating division.

CREDITS

Consideration must also be given to the policy with respect to credits resulting from the operation of the research and development department. Such credits can arise through the following:

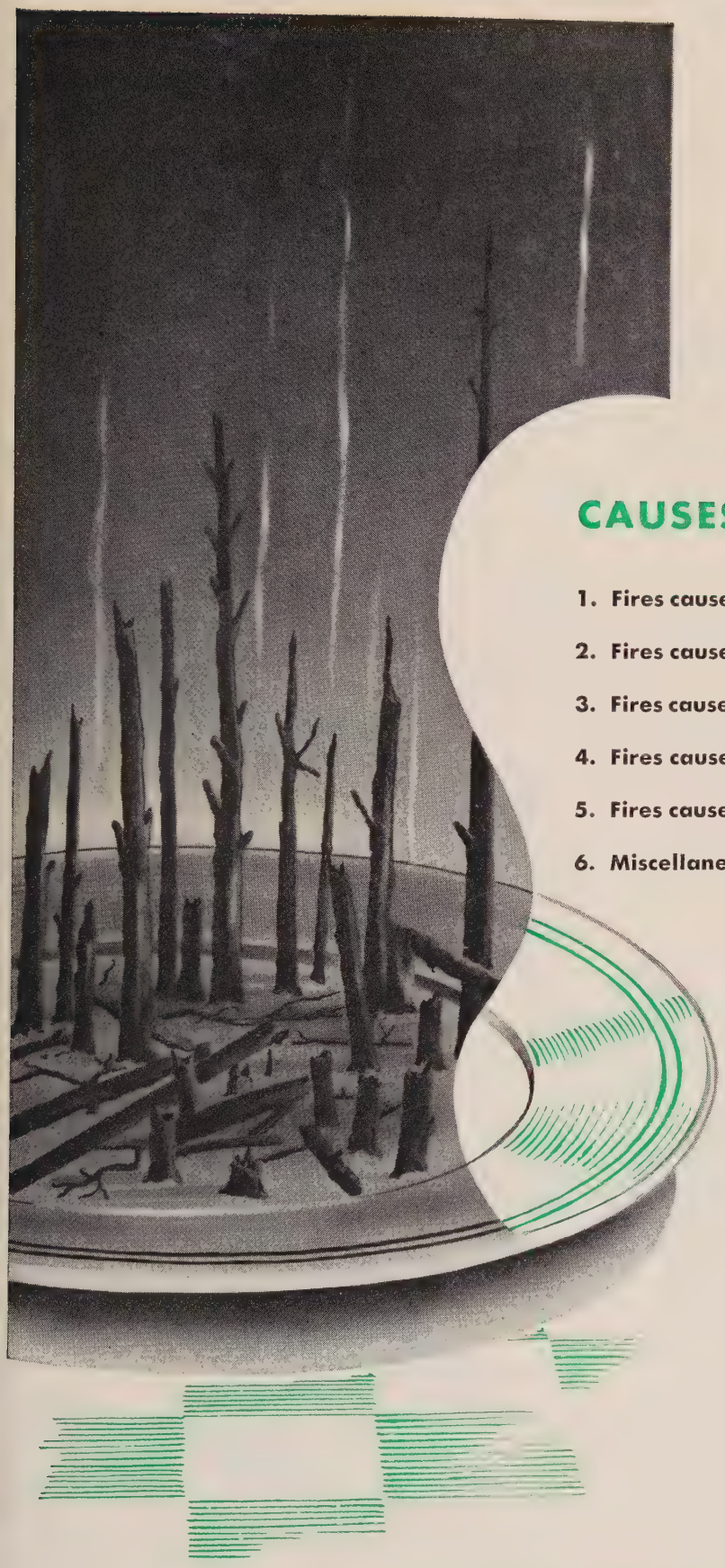
1. The sale of materials produced during the progress of the research and development department projects.
2. The sale of unusable expendable equipment or scrap resulting therefrom.
3. The transfer of expendable equipment or other materials to operating departments.
4. Charges to customers and others for technical services rendered.
5. Any other miscellaneous credits, depending upon the accounting policy of the organization.

In a situation where such credits may be sizable and regular in amount, it would be advisable to provide for them in the budget in the manner outlined above. In this way, management can watch this situation and see that all possible credits are given to the development department. However, where

Exhibit B

Research and Development Division Project Budget—Year Ending December 31, 1951

	Current budget	*Prior expenditure*	*Total authorized*
1. Present Products			
A. Projects in programs			
I. Product x improvement	5,000	15,000	20,000
II. Product y usage	10,000	10,500	20,500
III. Product z quality	10,000	7,500	17,500
Subtotal	25,000	33,000	58,000
B. New projects			
I. Product x new process	25,000		25,000
II. Product y quality control	30,000		30,000
III. Product z new use	20,000		20,000
Subtotal	75,000		75,000
Total present product	100,000	33,000	133,000
2. New Product Research			
A. Projects in progress			
I. Product xx	15,000	12,500	27,500
II. Product yy	10,000	5,000	15,000
Subtotal	25,000	17,500	42,500
B. New projects			
I. Product P	30,000		30,000
II. Product Q	25,000		25,000
III. Product R	10,000		10,000
Subtotal	65,000		65,000
Total new projects	90,000	17,500	107,500
3. Pure Research			
A. Projects in process			
I. Item S	5,000	3,500	8,500
II. Item T	7,000	3,000	10,000
Subtotal	12,000	6,500	18,500
B. New projects			
I. Item U	3,000		3,000
II. Item V	5,000		5,000
Subtotal	8,000		8,000
Total pure research	20,000	6,500	26,500
4. Sales Department Service			
A. Projects in progress			
I. Product x	7,000	1,000	8,000
II. Customer z	3,000	1,500	4,500
Subtotal	10,000	2,500	12,500
B. New projects			
I. Product y	2,000		2,000
II. Product Q	3,000		3,000
Subtotal	5,000		5,000
Total sales dept. service	15,000	2,500	17,500
5. Service Departments			
A. Library	10,000		10,000
B. Drafting room (general)	5,000		5,000
C. Stenographic and clerical	10,000		10,000
	25,000		25,000
6. Balance for Unauthorized Projects	50,000		50,000
	300,000	59,500	359,500



food for thought...

CAUSES OF FOREST FIRES

1. Fires caused by careless smokers...	19.8%
2. Fires caused by careless debris	18.7%
3. Fires caused by careless campers...	4.7%
4. Fires caused by incendiaries	30.3%
5. Fires caused by lightning.....	9.3%
6. Miscellaneous causes.....	17.2%

Protection of forests from fire is by far the biggest job in the vast new Tree Farming program taking root across the nation.

Hundreds of acres of trees can be destroyed in an hour by uncontrolled fire; and in the Pacific Northwest, for example, it takes about 80 years to grow a new crop of trees. Also, fire usually destroys all the trees in its path leaving no seed trees to replant the burned over area. This means months of work in planting thousands of seedlings by hand.

Weyerhaeuser loggers help out in fire prevention by controlled burning of slash in newly logged areas, as required by state law. Lookout stations and fire roads aid our fire-fighting crews and equipment. Cooperative fire-fighting and prevention methods have been worked out with other private companies and government agencies.

You, the public, can help the 2,980 Tree Farmers throughout the country by being more careful with fire in or near forest areas—and by reporting fires promptly. *Everybody* loses when a forest burns . . . locally and nationally, suppliers *and* users of lumber, woodpulp and other forest products.

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these credits are relatively limited in relation to the entire program, it would be far simpler not to provide for them in the budget, but to allow the division to dispose of these materials as they see fit and thereby reduce expenditures. In this manner, it might provide incentive for the department to dispose of unusable equipment and materials so as to make more funds available for expenditures toward the completion of projects.

PROJECT BUDGETS

We have discussed the establishment of a budget by classes of expenditures. However, the important phase of budgeting for research expenditures is the preparation of a budget for each project that will be undertaken during the period. This also can be relatively simple or quite elaborate depending upon the degree of management control desired for these expenditures. The simplest procedure would be merely to list the projects that will be undertaken during the period, showing the amount of the budget allocated to each. Provisions should be made in such a listing for additions to the list of projects during the period as new fields of research are entered into. The total of the amounts authorized for the several projects, in the aggregate, must agree with the amount budgeted by classes of expenditures.

A more detailed approach to budgeting research projects would be that in which projects are grouped under several headings. Major classifications would be as follows:

1. Improvement in the manufacture, quality, and usage of present products.
2. Research and development of new products.
3. Projects requested by customers or sales department.
4. Pure research, having no commercial value.
5. Service departments, such as research library, research clerical, and stenographic division, drafting room, etc. This should only provide for that portion not directly allocable to projects.
6. Balance available for projects to be authorized at a later date.

Under the first four of the above groupings, there could be a subheading establishing a specific budget for each project, as follows:

A. Budget for completion of projects authorized in prior periods.
B. Budget for projects to be started in current period.

Under each of these classifications, the individual projects are to be listed indicating the amount authorized for each. Exhibit B is a sample of the form that could be followed in setting up this portion of the budget. The total of all the items entered thereon, must agree with the expense budget.

The process of determining the project budget, whereby the amount of the aggregate authorized budget is broken down into projects, is one of deduction from known factors to unknown factors. The known factor, naturally, is the total amount that has been authorized. The unknown factor is the amount to be spent for each project.

The first step in logical sequence of allocation of this amount, is to determine the amount of money that would be spent to complete those projects in progress. Another portion, that is easily determinable is the cost of the service departments such as the library, drafting room, stenography, and clerical. After these two factors have been deducted from the total budget, the remainder is that amount that is available for new projects. The research directors and supervisors then determine what portion of this money should be allocated toward research with respect to those products being produced, for new products, or for pure research. The manner in which the totals for each of these major classifications is arrived at, depends upon the nature of the business, and the direction in which research and development effort is to be expended, based upon the policy of the organization toward research effort. Upon the determination of the amount to be spent for each of the major classifications, the next step is to apportion these amounts to the individual projects that are being considered for active investigation.

In this apportionment, no attempt should be made to show the manner in which funds are to be expended for each project. It is generally wise to do this, since the amount of materials, labor, or supplies that are to be used for each project cannot readily be determined and must be ascertained as the project progresses.

PERIODIC REVISION

Under the procedure outlined above, the management authorizes the research and development division to spend a specified sum in their over-all operation and also specifies the amount that they may spend for the various projects that are to be worked upon during the period. Efforts to pinpoint the budget in a manner where the class of expenditure for each project is developed, might limit the research department in such a way as to interfere with the smooth operational functions of the department. The outlined procedure provides sufficient flexibility so that the directors of research may use their own judgment in shifting the efforts within their division among the various projects that are undertaken.

It is advisable to revise the budgets for the several projects periodically. This can be done quarterly by issuing supplementary budgets. Amounts may be transferred from projects that are completed to "Balance for Unauthorized Projects" and amounts may be transferred from "Balance for Unauthorized Projects" to new projects, or to increase projects in progress because of increased requirements.

In preparing the budget by projects, provision must be made to indicate the amount that had been expended during a prior period, it being assumed that such amounts, plus that budget for the current period will be the total amount authorized for each project. The total budget for the individual project is an extremely important guide for management, since control must be maintained of the total expenditure for deciding when the project should be abandoned or continued to its successful fruition. The budgeting for research projects as such, must be for a longer period than just for a current budget accounting period. It must be recognized that in some instances, a long-range program be established and provisions should be made so that the full-range program can be completed without hindrance from financial executives.

APPROVAL

Upon the completion of the expense and project budget, approval by top management is desirable and usually required. A letter of transmittal with the budget outlining the high spots and indicating the anticipated results of the research effort is quite helpful for obtaining a prompt approval. In preparing the budget a realistic and practical approach should have been used, so as to enable management to readily foresee the beneficial results of the proposed efforts. The budget should not be top heavy on pure research or nonproductive work, and depending upon the nature of the business, should have sufficient stress upon improvement in present products, either from the production, quality, or use viewpoint and upon the development of new products. This is desirable to obtain the proper interest, enthusiasm, and approval of top management.

This budgeting procedure is only of value, if expenditures made are properly recorded in accordance with the budget, so that comparisons can be made between the amounts actually expended and that authorized. Records should be maintained and monthly or quarterly reports should be prepared so that those responsible for the functions of the research department can control their expenditures in line with the budget and determine the amount of funds available for subsequent operations.

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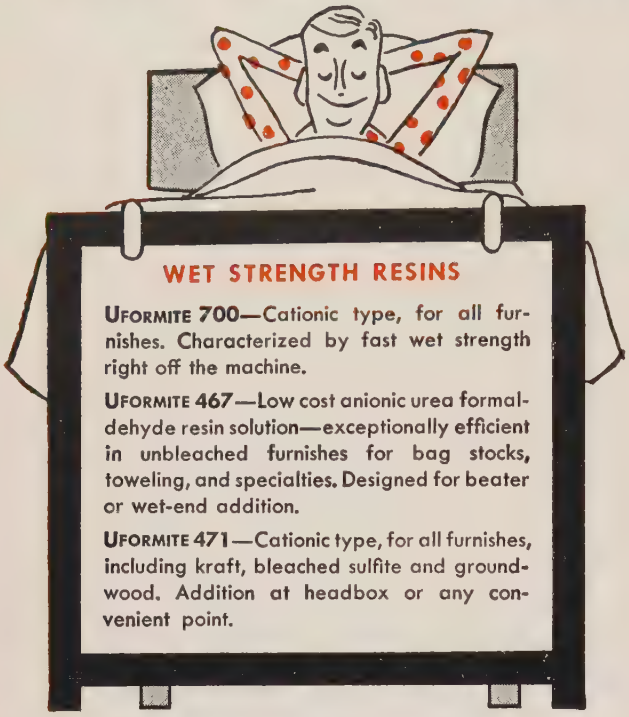
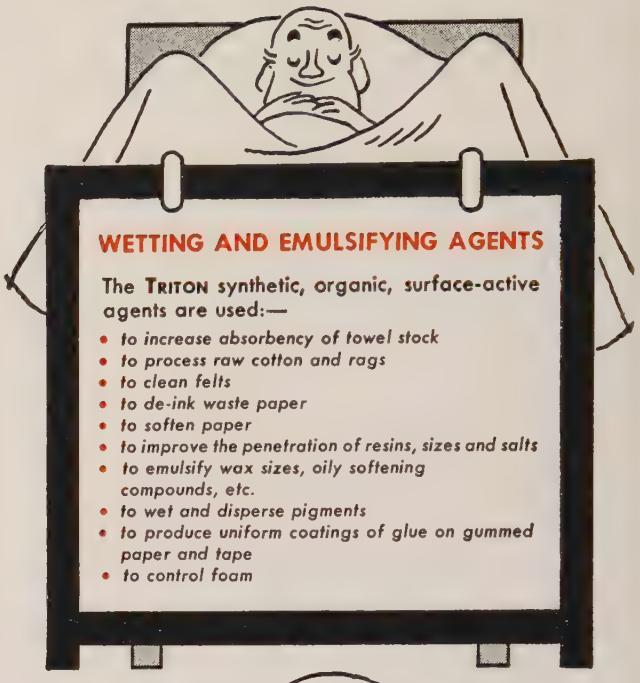


WET STRENGTH RESINS

UFORMITE 700—Cationic type, for all furnishes. Characterized by fast wet strength right off the machine.

UFORMITE 467—Low cost anionic urea formaldehyde resin solution—exceptionally efficient in unbleached furnishes for bag stocks, toweling, and specialties. Designed for beater or wet-end addition.

UFORMITE 471—Cationic type, for all furnishes, including kraft, bleached sulfite and groundwood. Addition at headbox or any convenient point.



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The **TRITON** synthetic, organic, surface-active agents are used:—

- *to increase absorbency of towel stock*
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- *to de-ink waste paper*
- *to soften paper*
- *to improve the penetration of resins, sizes and salts*
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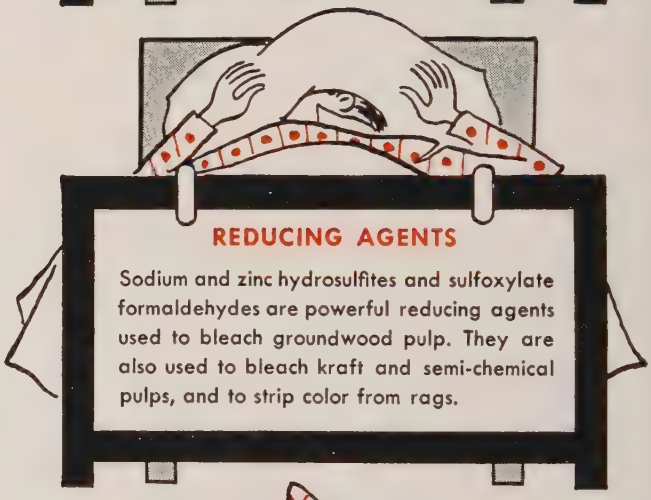
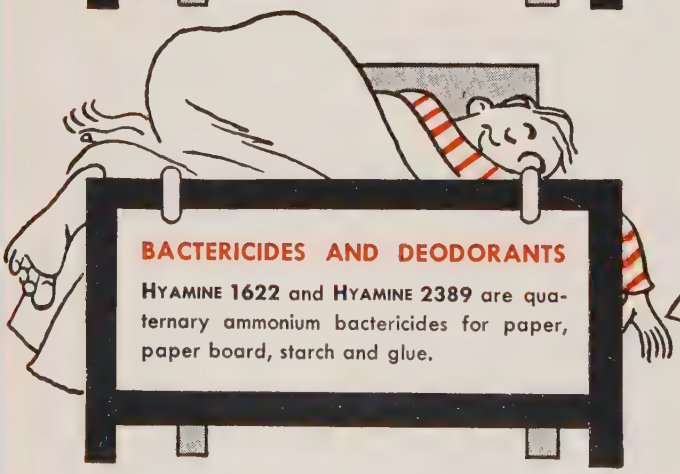


REDUCING AGENTS

Sodium and zinc hydrosulfites and sulfoxylate formaldehydes are powerful reducing agents used to bleach groundwood pulp. They are also used to bleach kraft and semi-chemical pulps, and to strip color from rags.



BACTERICIDES AND DEODORANTS

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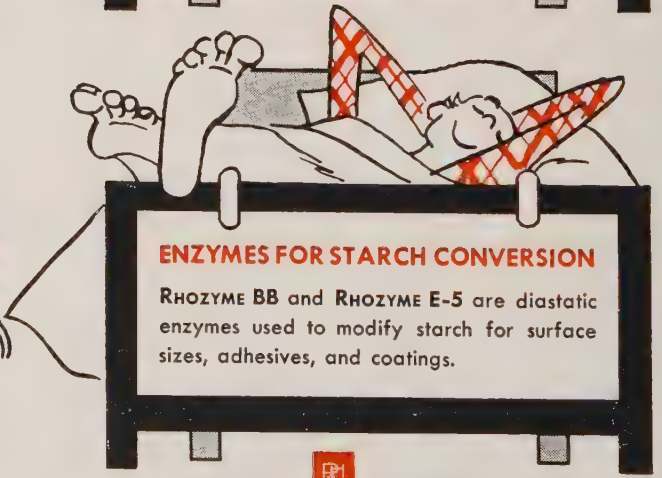

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The Properties of a New Vinyl Chloride–Vinylidene Chloride Latex for Paper Coating

E. K. STILBERT and H. L. CLACK

A new vinyl chloride–vinylidene chloride–latex is described. The properties of this synthetic latex are outlined. Detailed information is presented on the methods of handling and formulating the latex to obtain useful decorative and protective coatings. Data on the properties of coated papers are presented which indicate that this latex will find wide use as a general-purpose, vinyl resin coating material. A review of the vinyl chloride–vinylidene chloride–copolymer system shows that a latex based on a high proportion of vinyl chloride in the copolymer deposits films with excellent color stability; toughness; grease, water, and chemical resistance. It can be formulated to obtain a fair degree of moisture vapor resistance. Such a latex is being made commercially under the name, Dow Latex 744-B. This new vinyl copolymer latex possesses excellent mechanical stability. It is widely compatible with water soluble and water dispersible materials. Since it does not form a film with simple air-drying, special formulating steps are required to obtain useful films. Due to the excellent stability of the latex and compatibility of the polymer excellent films can be obtained by using a wide variety of modifiers incorporated with standard mixing equipment.

THERE is a general industry-wide interest in synthetic latices, but most of this is centered around the soft, rubbery, tacky types. These are used extensively in the manufacture of wet adhesives or as binders for pigments and fibers in the paint, paper, floor covering, textile, and leather industries. For some applications there is a trend to harder types. A notable example is the paint field where a low pigment ratio is desired to obtain functional properties in the dried film. However, the development of the completely nontacky, surface-coating latices has been relatively slow. In the paper industry lack of understanding of the properties and handling of these latices have been important factors in retarding their growth.

In the manufacture of latices, the film-forming qualities developed in the resin are dependent to a major degree on the choice of monomers. Monomers such as butadiene and ethyl acrylate form very soft polymers. Monomers such as styrene, acrylonitrile, vinyl chloride, and vinylidene chloride form hard polymers. To get proper balance, "soft" and "hard" monomers are copolymerized in proportions that produce copolymers of the "binder" type. To produce tough, nontacky coating latices the "hard" monomers may be copolymerized in the proper ratio or a "hard" monomer may be copolymerized with a low proportion of "soft" monomer.

Vinyl chloride is a large-volume, low-cost monomer extensively used in the manufacture of plastic materials. It may be polymerized without modification to produce polyvinyl chloride, a product familiar to almost everyone in the form of drapes, shower curtains, and upholstery material. It may be copolymerized with vinylidene chloride, vinyl acetate, ethyl acrylate, etc., to produce products with different properties. Such plastic materials have been available commercially since about 1930.

There are several polymerization methods that could be used for the manufacture of vinyl chloride polymer and copolymer resins. These have been well described by Barron (*1*) who has outlined the advantages of the emulsion polymerization process.

By this process the monomers are reacted in water in the presence of emulsifying agent. The synthetic latex which results from this process is coagulated and dried to form the resin. By special treatment the resin can be made stable in the synthetic latex form. Synthetic latices of this type have been commercially available in the United States since 1943. This paper describes a vinyl chloride–vinylidene chloride latex that is particularly suited to the surface coating of paper.

Vinylidene chloride has never been extensively used as the sole monomer in the manufacture of plastic materials due to the high order of crystallinity of its polymers and their resultant insolubility and incompatibility. Vinyl chloride has been a commonly used comonomer. The properties of these resins have been fully described by Reinhardt (*2*) and Alexander (*3*). Other monomers, such as acrylonitrile, ethyl acrylate, etc., have been used for making resins with special properties. Copolymer resins comprising high proportions of vinylidene chloride to its comonomer have been marketed as saran resins since 1937. The first commercial products were copolymers with vinyl chloride. In 1943 a vinylidene chloride–acrylonitrile copolymer resin was introduced commercially.

To better understand the copolymer system and the relationship between composition and properties refer to Fig. 1. This figure does not contain curves based on exact data. It is designed to summarize the data of Schick (*4*) and show the trend of physical properties as the ratio of vinyl chloride to vinylidene chloride is changed in the manufacture of copolymers. It is evident from these curves that copolymers high in vinylidene chloride are very low in solubility, color stability, and elongation. They are high-melting and have moderate tensile strength. Sarge (*5*) has determined the high order of moisture vapor and gas impermeability of these resins. The strength of the high vinylidene chloride containing resins may be greatly increased by orienting them during fabrication.

Minimum tensile strength and flow temperature, and maximum elongation and solubility are typical

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properties of copolymers containing 40 to 50% vinylidene chloride. As the proportion of vinylidene chloride decreases, the tensile strength again approaches and finally surpasses that of the high vinylidene chloride resins. In addition the high vinyl chloride copolymers are color stable, more soluble, and tougher. They do not have the excellent moisture vapor and gas impermeability of high vinylidene chloride copolymers

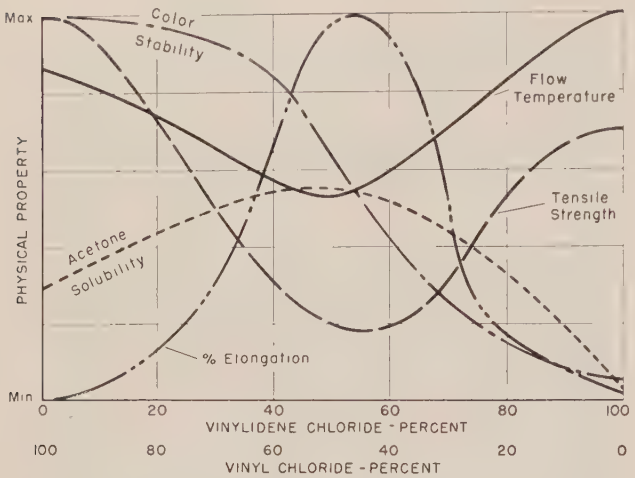

Fig. 1. Physical properties of vinyl chloride–vinylidene chloride copolymers

but they have many superior properties for general use. Such copolymers have been available commercially in resin form since 1943.

It is apparent that the excellent properties of the high vinyl chloride copolymers in their dry form cannot be readily utilized by the paper industry due to application difficulties. Such resins in dispersed form as synthetic latices might readily be adapted to present paper industry converting practices. The development of a high vinyl chloride copolymer latex has been undertaken with this in mind. A range of copolymers has been evaluated to determine the optimum copolymer for film properties and compatibility with modifying materials. The product that has been chosen from this work has been designated as Dow Latex 744-B.

Table I. Typical Properties of the Latex

pH	8.0 ± 0.5
Surface tension, dynes/cm.	34.0 – 35.0
Percent evaporated solids	50.0 ± 0.5
Specific gravity at 25 °C.	1.195 ± 0.004
Weight per gallon, pounds	10
Viscosity, cp.	<20
Pounds of solids per gallon	5
Particle size, average mmu	< 0.2

The information contained in this paper has been obtained in the laboratory by working with relatively small-sized samples. Since latices are somewhat sensitive systems, slight changes in handling procedures may be necessary when the quantities of materials used are greatly increased, as in normal commercial operations.

LATEX PROPERTIES

A listing of the general properties of this vinyl chloride–vinylidene chloride latex is contained in Tables I and II. The latex has a relatively low surface tension. When dried, a nonflammable, high-melting, white powder is deposited. In order to form a film the latex must be modified with film-forming latices, plasticizer emulsions, or certain liquid plasticizers. Generally useful compositions will contain a small amount of thickener since the viscosity of the latex is very low.

Table II. Typical Properties of the Latex Solids

Specific gravity at 25 °C.	1.48
Melting point, °C.	164
Heat and light stability	Excellent
Burning rate	Nonflammable
Refractive index	1.539 ± 0.003
Pounds per TAPPI ream per mil	26.7
Square inches per pound per mil	18,730

Figure 2 is a typical electron micrograph of this latex. Although the particles vary considerably in size, most of them are under 0.2 mmu. The long, sharp shadow indicates that the unmodified particles are not deformed during drying. The random size distribution of particles under 0.2 mmu aids film formation when plasticizer is blended with this latex. Detailed information on film formation is presented in another part of this paper.

Stability to Electrolytes

The latex is of the anionic type which may be readily modified by blending with water emulsions, dispersions, or solutions of other materials. Generally such dispersions must be used in alkaline or neutral systems to obtain stable mixtures with the latex. Certain water dispersible solvents are exceptions to this rule. The latex is sensitive to divalent and trivalent cations and

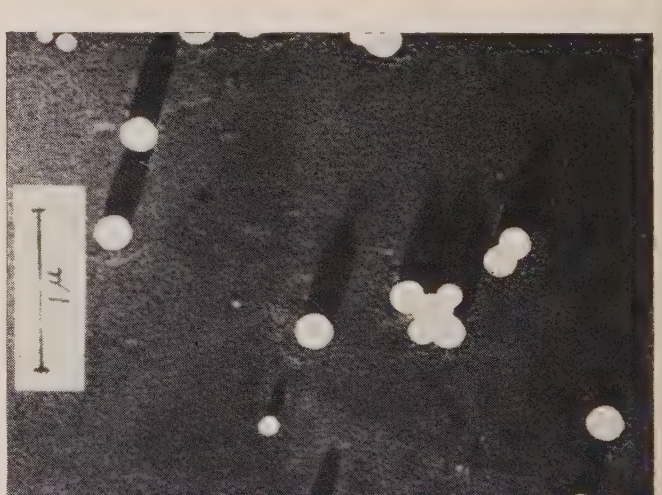

Fig. 2. Electron micrograph of Dow Latex 744-B

care should be taken to eliminate or immobilize them when the latex is blended with other materials. Hard water contains soluble calcium, magnesium, and iron that can be quite troublesome unless water softeners are used. The latex is very stable to monovalent cations so they may be used in relatively large quantities if desired, i.e., for rust inhibition or fire retardancy. Table III contains data on the resistance of the latex

to the gradual addition while stirring of 5% salt solutions.

Stability to pH Variations

The pH of the latex has some effect on its stability. The following acids and bases were used to adjust the pH of the latex from 1 to 12: hydrochloric acid, sulphuric acid, phosphoric acid, sodium hydroxide, and ammonium hydroxide.

At a pH less than 3 some coagulation occurred after 2 weeks but none occurred after 1 week. At a pH above 9 no coagulation occurred but the pH did drift downward. Results were independent of the reagent used. Tests were discontinued after 3 weeks.

Table III. Electrolyte Tolerance of the Latex

5% Solution of	*Parts per 100 parts latex to cause initial coagulation*
Sodium chloride ($NaCl$)	100+
Tetrasodium pyrophosphate ($Na_4P_2O_7$)	100+
Ammonium acid phosphate ($NH_4H_2PO_4$)	100+
Potassium dichromate ($K_2Cr_2O_7$)	100+
Sodium nitrite ($NaNO_2$)	100+
Calcium chloride ($CaCl_2$)	0.2
Aluminum chloride ($AlCl_3$)	0.3

Thickening

When the latex is used as a clear or lightly pigmented coating it normally requires a small amount of a thickening agent to obtain an application viscosity. Information on the thickening characteristics of such agents when added to a latex-plasticizer system is given in Figs. 3 and 4. Plasticized systems are illustrated because unplasticized latex is not film-forming and for most applications a plasticizer will be present when the thickener is added. Ammonium alginate is a very efficient thickener at concentrations up to about 0.5% thickener solids on latex solids. For viscosities above 1000 cp., determined with the Brookfield synchro-lectric viscometer, methylcellulose, 15 cp. viscosity type, is the most efficient thickener and is very compatible with the resin. The viscosity of these systems shows very little change after standing 24 hours at 75°F. Isolated soybean protein is an effective thickener at the higher concentrations. Where such proportions of thickener can be tolerated in the dried composition, it may be preferred because of its colloidal stabilizing effect on the latex and the better flow properties of latex formulations containing it.

Water-Soluble and Water-Dispersed Modifiers

For special properties of the deposited film it may be desirable to add any of a number of modifying latices or resins to the latex. Such materials must generally be added as water dispersions or solutions. Table IV contains information on many typical materials that might be used to modify the latex. The list is in no way complete. It does, however, demonstrate the wide range of compatibility of the resin.

Table IV. The Compatibility of Unplasticized Latex with Water-Soluble and Water-Dispersible Materials

Modifier		*The appearance of films composed of modifier and Dow Latex 744-B solids in ratios of*		
Trade name	*Chemical composition*	*1 part to 3 parts 744-B*	*1 part to 1 part 744-B*	*3 parts to 1 part 744-B*
GRS Latex, Type 4	Styrene-butadiene copolymer latex	Not film-forming	Sl. hazy, checked brittle	Sl. hazy, rubbery, strong
Dow Latex 512-K	Styrene-butadiene copolymer latex	Not film-forming	Clear, glossy, strong	Clear, glossy, strong
Dow Latex 529-K	Styrene-butadiene copolymer latex	. . .	Not film-forming	. . .
Dow Latex 580-G	Polystyrene latex	. . .	Not film-forming	. . .
Chemigum Latex 101A	Styrene-butadiene copolymer latex	Not film-forming	Sl. checked, hazy, brittle	Sl. hazy, rubbery
Neoprene Latex 571	Polychloroprene latex	Not film-forming	Clear, weak	Clear, rubbery, strong
Neoprene Latex 842A	Polychloroprene latex	Not film-forming	Clear, glossy, flexible	Clear, glossy, flexible
Rhoplex FRN	Acrylic emulsion	Not film-forming	Hazy, sl. gloss, rubbery	Hazy, sl. gloss, rubbery
Rhoplex WC-9	Acrylic emulsion	Cloudy, glossy, poor film	Hazy, glossy	Hazy, glossy, elastic
Rhoplex WN-80	Acrylic emulsion	Coagulated the latex		
Darex X52-L	Polyvinyl acetate emulsion	Not film-forming	Coagulated the latex	
Saran Latex F122-A20	Vinylidene chloride acrylonitrile copolymer latex	Not film-forming	Hazy, checked	Hazy, brittle
G. E. Resin Emulsion R-301-14	. . .	Not film-forming	Sl. hazy, checked, brittle	Sl. hazy, sl. brittle
Dresinol 210B	Modified rosin emulsion	Not film-forming	Cloudy, brittle	Hazy, dull
Alpha protein	Isolated soybean protein	Not film-forming	Sl. hazy, flaky	Sl. hazy, brittle, adherent
Soybean flour	Crude soybean protein	Hazy, dull, brittle	Hazy, dull, brittle, adherent	Hazy, dull, brittle
Casein, papermakers' grade	. . .	Brittle flakes	Hazy, dull, brittle, adherent	Hazy, dull, brittle, adherent
Oxidized corn starch	. . .	Not film-forming	Hazy, dull, checked, adherent	Hazy, dull, checked, adherent
Glue, hide	. .	Hazy, granular	Hard, adherent	Hard, adherent
Gum arabic	Natural resin	Coagulated the latex		
Keltex	Sodium alginate	Cloudy, granular, brittle	Hazy, dull, hard, adherent	Hazy, dull
Shellac	. . .	Flaky, noncontinuous	Flaky, noncontinuous	Flaky, noncontinuous
Methocel HG, 25 cp.	Cellulose ether	Not film-forming	Hazy, granular	Hazy, granular
CMC, low viscosity	Sodium carboxymethylcellulose	Hazy, dull, flaky	Hazy, dull, granular	Hazy, dull, granular
Uformite 470	Urea-formaldehyde resin	. . .	Clear, hard, checked	Clear, hard, adherent
Beckamine P-468	Ketone-aldehyde resin	Coagulated the latex		

The term "compatibility," when used to describe blends of latices with other materials, has a slightly different shade of meaning than it does in normal resin technology. Normally materials are blended together in a common solvent. Compatibility is determined by the properties of the dried composition after the solvent is evaporated. Latices may be readily blended with water solutions of other materials even though the

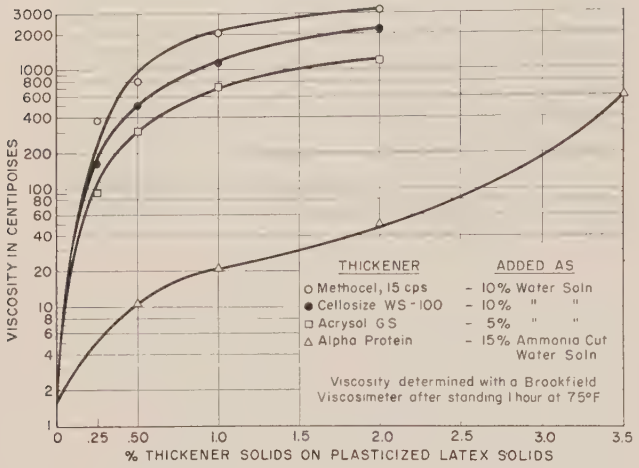
VISCOSITY IN CENTIPOISES
% THICKENER SOLIDS ON PLASTICIZED LATEX SOLIDS
THICKENER
ADDED AS
○ Methocel, 15 cps - 10% Water Soln
● Cellosize WS-100 - 10% " "
□ Acrysol GS - 5% " "
△ Alpha Protein - 15% Ammonia Cut Water Soln
Viscosity determined with a Brookfield Viscosimeter after standing 1 hour at 75°F

Fig. 3. The effect of thickeners on the plasticized latex 75/25 latex/2-biphenylyl diphenyl phosphate

resin particles themselves are completely hydrophobic. In this manner, for instance, hide glue may be modified with a vinyl copolymer resin. Because the resin particles are so small, an intimate blend of the two normally "incompatible" materials is obtained and the dried film from such a composition may possess a blend of the properties of both materials. Perhaps an analogy could be drawn between such compositions and metal alloys.

The materials in Table IV are in most instances listed by their brand name as well as their chemical composition. Even though different companies prepare products having the same general composition, they differ enough in chemical purity, molecular weight, and dispersing agents used, that it is absolutely essential to know the brand name of the product in order to predict its performance.

The latex will tolerate the addition of varying quantities of water-miscible solvents. In many instances the tolerance of the latex for these solvents can be improved by first diluting the solvent with water. Such solvents are often added to latex compositions for the following reasons: to lower the freezing point; to promote film formation; to provide a hygroscopic film; to dissolve water insoluble additives, e.g., preservatives or stabilizers; to promote adhesion; to provide strippability; and to kill foam.

Table V lists the number of grams of solvent necessary to produce initial coagulation in 100 grams of latex when the solvent is added (1) undiluted and (2) diluted with an equal part of water.

It should be recognized that time is an important factor in evaluating the stability of the latex in the presence of water-miscible solvents. This factor was checked by mixing the following solvents as one to one solvent-water mixtures with the latex to obtain 70–30 and 85–15 blends of latex solids and solvent: diethylene glycol monoethyl ether acetate, ethylene glycol, propylene glycol, propylene glycol methyl ether, dipropylene glycol methyl ether, and tripropylene glycol methyl ether.

Table V. The Tolerance of the Latex for Water-Miscible Liquids

Solvent	*Grams of solvent per 100 grams latex to cause initial coagulation added as 100% Solvent by weight*	*50% Aqueous solvent by weight*
Acetone	0.6	1.2
Methyl ethyl ketone	0.6	6.3[a]
Methanol	1.2	6.6
Ethanol (95%)	4.2	4.6
Isopropanol	5.4	11.2
Ethylene glycol	100+	..
Propylene glycol	50+ (thickens)	23.6 (thickens)
Glycerine	100+	..
Propylene glycol methyl ether	0.8	30+
Dipropylene glycol methyl ether	2.2	30+
Tripropylene glycol methyl ether	8.8	30+
Triethanol amine	47	7.2
Diethylene glycol monoethyl ether acetate	1.0	20–30
Ethyl lactate	6.2	..

[a] Added as a 35% aqueous solution by weight.

All of the 85–15 blends maintained constant viscosities over the week of the test.

In the 70–30 series only diethylene glycol monoethyl ether acetate caused excessive thickening of the latex in a week's time. Propylene glycol, propylene glycol methyl ether and tripropylene glycol methyl ether caused some thickening after 72 hours but this thickening disappeared after 1 week.

FILM FORMATION

Since Dow Latex 744-B is not a film-forming latex, it must be modified to obtain useful films. In general

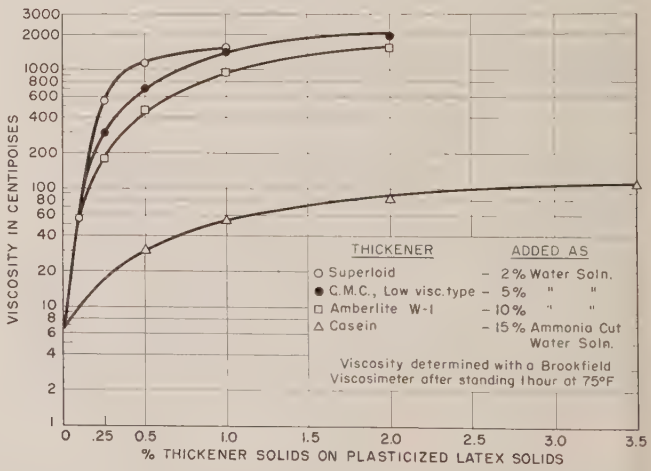
VISCOSITY IN CENTIPOISES
% THICKENER SOLIDS ON PLASTICIZED LATEX SOLIDS
THICKENER
ADDED AS
○ Superloid - 2% Water Soln.
● C.M.C., Low visc. type - 5% " "
□ Amberlite W-1 - 10% " "
△ Casein - 15% Ammonia Cut Water Soln.
Viscosity determined with a Brookfield Viscosimeter after standing 1 hour at 75°F

Fig. 4. The effect of thickeners on the plasticized latex 75/25 latex/2-biphenylyl diphenyl phosphate

this is readily accomplished with inexpensive equipment and a wide range of commercially available modifiers which act as temporary or permanent plasticizers. To obtain stable mixtures they must be added as water solutions or dispersions.

Plasticizers for the latex may be conveniently classified as follows:

1. Synthetic latices.
2. Chemical and polymeric plasticizers.
   (a) Require special dispersion techniques.
   (b) Require no special dispersion techniques.
3. Water-miscible temporary plasticizers.

1. *Synthetic Latices.* Most anionic synthetic latices may be blended in any proportion with this vinyl chloride–vinylidene chloride latex. Those that form soft, rubbery films will act as permanent plasticizers for the polymer. They will aid film formation in proportion to their softness and compatibility with the polymer.

2. *Chemical and Polymeric Plasticizers.* (a) *Require Special Dispersion Techniques.* The most common types of plasticizers for a vinyl copolymer resin are the chemical and polymeric types. These types are generally viscous liquids that are not readily miscible with water. In order to obtain useful films it is necessary to disperse the plasticizer by one of the following procedures to obtain stable plasticizer-resin compositions:

(1) By blending with a 50% plasticizer emulsion prepared as follows:

Plasticizer	100 parts
Alkylated arylpolyether alcohol	5 parts
28% Ammonium hydroxide	2 parts
Water	93 parts

The ammonia-water solution is added very slowly and with good stirring to the plasticizer containing the alkylated arylpolyether alcohol. A thick water-in-oil emulsion is formed at first, but this inverts to an oil-in-water emulsion as more water is added. The emulsion is stirred vigorously after all of the water has been added. A stable, thin emulsion containing 50% by weight of plasticizer is obtained. Passage through a colloid mill will give added stability to emulsions prepared by this method.

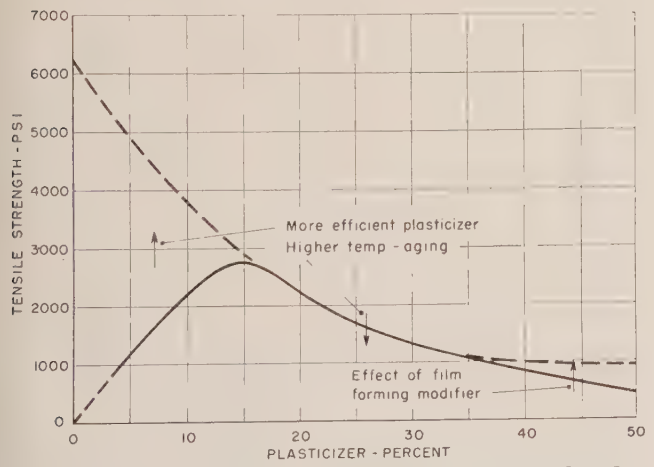

Fig. 5. Factors affecting the tensile strength of the plasticized latex

(2) By blending with the plasticizer-thickener mixtures, the thickener which is used with the latex can be used to suspend the plasticizer. The latex can then be stirred into the thickener-plasticizer mixture to give a good stable plasticized latex. Methylcellulose is particularly useful in this procedure and it is normally used as a 5% solution. The amount used is generally about $^1/_2$ to 1% as dry methylcellulose based on the latex solids. The following example illustrates the preparation of a plasticized formulation:

Plasticizer	20 parts
Latex (50% solids)	160 parts
Methylcellulose 15 cp.-type (5% aqueous solution)	8 to 16 parts

The plasticizer is mixed with the methylcellulose solution using the best available agitation. The latex

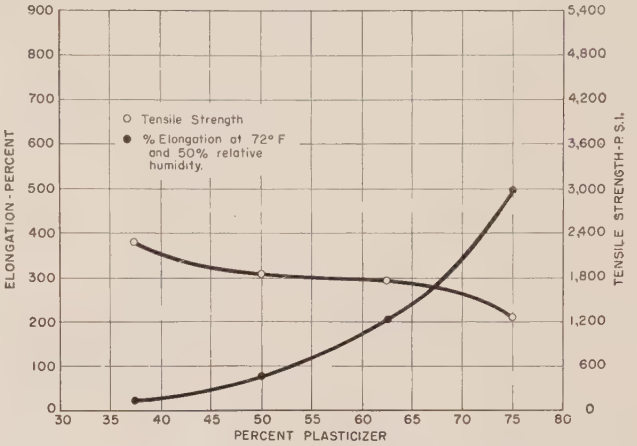
ELONGATION - PERCENT
TENSILE STRENGTH - P.S.I.
PERCENT PLASTICIZER
O Tensile Strength
● % Elongation at 72° F and 50% relative humidity.

Fig. 6. The plasticization of the latex with Dow Latex 512-K

is then stirred in, using a minimum of agitation. Best stability will be found with the higher percentages of methylcellulose.

(3) By blending with the plasticizer-pigment-thickener mixtures in pigmented compositions, the plasticizer can be dispersed in the paste of pigment and thickener or stabilizer. The latex again is added with minimum agitation to the paste containing the plasticizer.

(b) *Require no Special Dispersion Techniques.* Triethylene glycol di-2-ethylbutyrate is a chemical plasticizer that can be stirred directly into the latex. It should be added slowly while the latex is stirred slowly. If used as directed, it will not coagulate the latex but is apparently immediately absorbed by the resin particles.

3. *Water-Miscible Temporary Plasticizer.* For many applications of vinyl resins the use of plasticizer is desirable to obtain extra flexibility in the film. In such instances there is no difficulty in forming continuous films using latex since the plasticizer aids film formation. However, when the unmodified resin is preferred the problem of film formation becomes complex. Since the copolymer is thermoplastic, a film could be formed by evaporation of the water and subsequent fusion of the resin particles above their melting point. For commercial operations this is impractical. However, excellent films may be obtained at normal drying temperatures of 70 to 120°C. by incorporating a fugitive plasticizer which softens the latex particles and permits film formation, but which will finally evaporate at the drying temperature. There are several water-miscible solvents that will function in this manner. To obtain stable latex compositions it is necessary to first dilute them with water. A convenient concentration is a 50% aqueous mixture since the

latex itself is 50% solids. The system using diethylene glycol monoethyl ether acetate has been investigated but it is known that useful films may also be obtained with ethylene glycol, propylene glycol, glycerine, dipropylene glycol methyl ether, tripropylene glycol methyl

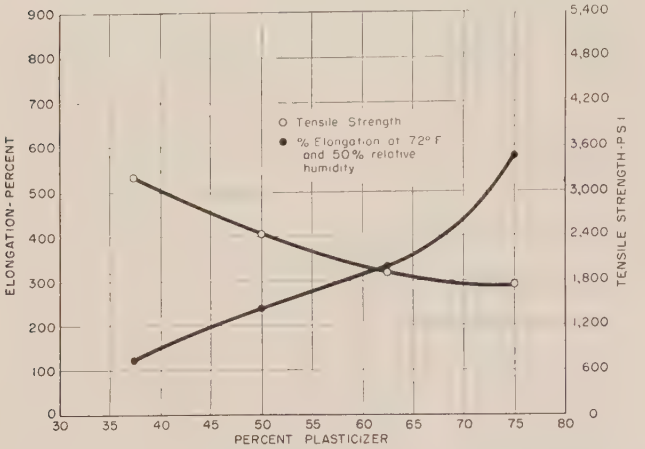
ELONGATION - PERCENT
TENSILE STRENGTH - P S I
PERCENT PLASTICIZER
O Tensile Strength
● % Elongation at 72° F and 50% relative humidity

Fig. 7. The plasticization of the latex with Rhoplex FRN

ether, ethylene glycol monoethyl ether acetate, or glycol diacetate.

Aging of Plasticized Latex

Certain plasticizers require an aging period in the formulated latex composition in order to form films of maximum clarity and toughness. Of the plasticizers discussed in this paper only 2-biphenylyl diphenyl phosphate and the polyester require this special handling. If these plasticizers are blended with the latex and immediately cast into films, the films are hazy, weak, and, perhaps, tacky. By aging the wet composition for several days in a warm room, or for 12 to 20 hours at 50 to 60°C., the film properties are greatly improved. Pigmented compositions containing these plasticizers do not require as long an aging period as clear film compositions.

FILM PROPERTIES

The film properties of plasticized latex depend on the plasticizer used, the quantity of plasticizer used, and the temperature and age of the plasticized latex. The property most desired from a given film determines the order in which these factors are considered.

Tensile Strength–Per Cent Elongation of Plasticized Films

Figure 5 shows a tensile strength vs. per cent plasticizer curve for a typical plasticized latex film. At room temperature the latex alone does not form a film and the tensile strength is zero. As plasticizer is added, a film is formed and the tensile strength increases. When completely continuous films are formed, additional plasticizer only serves to soften the film and the tensile strength decreases.

When a film forming material, such as another latex, is used as a plasticizer, the tensile strength of the film at high concentrations of the modifying material is higher than the tensile strength obtained with an ordinary plasticizer.

Any technique that improves the film-forming properties of the latex at low plasticizer concentrations increases the tensile strength of its films. This can be accomplished by using a more efficient plasticizer, using a higher temperature, or aging the plasticizer-latex emulsion. The dotted line at the left of Fig. 5 indicates the maximum possible tensile strength is about 6200 p.s.i. This is a value obtained from heat-fabricated tensile bars using solid polymer having the same vinyl chloride–vinylidene chloride ratio as the latex and containing no plasticizer.

At high plasticizer contents, as shown in Fig. 5, the above techniques lower the tensile strength because of the increased solvent action of the plasticizer.

Figures 6 through 14 are tensile strength-elongation curves for latex films plasticized with varying quantities of different types of plasticizers. The method used is comparable to TAPPI Standard T 404 m-47, except that samples 2.0 inches long were used.

The following types, as discussed under the section of film formation, are represented in these figures.

1. Synthetic latices
   Dow Latex 512-K-styrene-butadiene copolymer latex (Fig. 6)
   Rhoplex FRN—modified polyacrylate emulsion (Fig. 7)
   Neoprene 571—polychloroprene latex (Fig. 8)
2. Chemical and polymeric plasticizers
   (a) Require special dispersion techniques
   Dow Plasticizer 5—2-biphenylyl diphenyl phosphate (Fig. 9)
   Santicizer 141—alkyl arylphosphate (Fig. 10)
   Glyptal 2557—polyester (Fig. 11)
   Kronisol—dibutoxyethyl phthalate (Fig. 12)
   (b) Requires no special dispersion technique
   Flexol 3GH—triethylene glycol di-2-ethylbutyrate (Fig. 13)
3. Water-miscible plasticizers—nonpermanent type
   Diethylene glycol monoethyl ether acetate (Fig. 14)

By the use of the diethylene glycol derivative as a nonpermanent plasticizer and drying the films at 100°

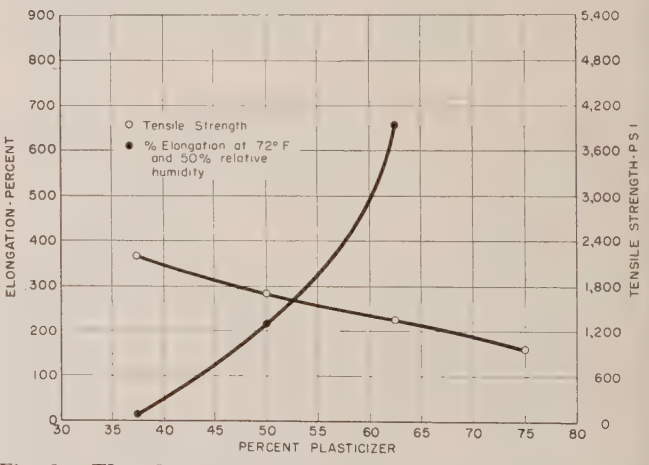
ELONGATION - PERCENT
TENSILE STRENGTH - P S I
PERCENT PLASTICIZER
O Tensile Strength
● % Elongation at 72° F and 50% relative humidity

Fig. 8. The plasticization of the latex with Neoprene 571

C., tensile strengths can be obtained that closely approach the theoretical maximum of 6200 p.s.i.

Moisture-Vapor Transmission of Plasticized Films

The type of plasticizer used with the latex has a significant effect on the moisture-vapor transmission. Figure 15 shows the effect of increasing quantities of a chemical plasticizer and a polymeric plasticizer on moisture-vapor transmission. The difference in thickness probably has some effect on moisture-vapor transmis-

sion, but, in spite of that, Fig. 15 illustrates the rule that the more efficient chemical plasticizers give higher moisture-vapor transmissions than the less efficient polymeric plasticizers.

The moisture-vapor transmission for 0% plasticizer was obtained with diethylene glycol monoethyl ether acetate and special film-forming techniques.

The Chemical Resistance of Coatings Made from Plasticized Latex

Cedar test panels were multiple brush-coated with plasticized latex to insure a completely continuous film. The panels were dried under infrared lamps and were then exposed for 1 week at room temperature to a variety of test reagents. The results were recorded in Table VI. The resistance is somewhat dependent on the plasticizer used. The resistance of the plasticized films to many strong acids and bases is only fair but this can be improved by using fugitive plasticizer in the films.

Other Properties of Plasticized Films

The effect of different plasticizers on the following properties of the latex films is given in Table VII: (a) light stability, (b) heat stability, and (c) low temperature flexibility.

(a) *Light Stability.* The light stability of clear, plasticized films was determined in a single-arc Atlas rotating fadeometer. Failure was reported when a crack appeared in the exposed film when it was quickly creased. Generally some discoloration occurred shortly before failure. The light stability of the films seemed to be limited by the ultraviolet light stability of the plasticizer. Dioctyl phthalate, the alkyl aryl phosphate, dibutyl sebacate, and the polyester gave exceptionally light stable films.

(b) *Heat Stability.* The heat stability of plasticized

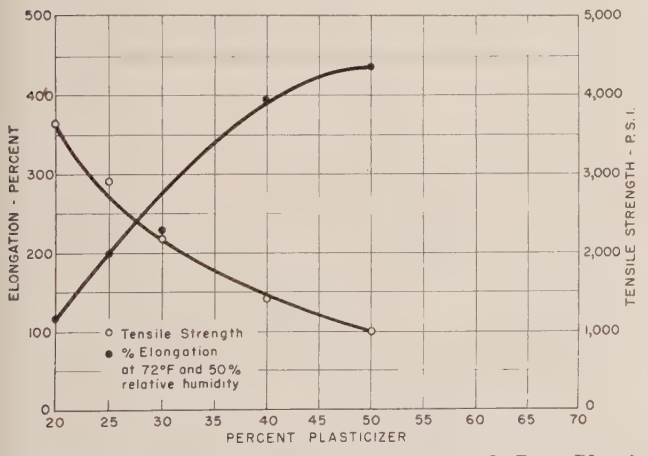
ELONGATION - PERCENT
TENSILE STRENGTH - P.S.I.
PERCENT PLASTICIZER
O Tensile Strength
● % Elongation at 72°F and 50% relative humidity

Fig. 9. The plasticization of the latex with Dow Plasticizer 5

latex films was determined on films containing enough plasticizer to obtain the same degree of flexibility throughout the series. The tensile strength of these films was obtained (by the method previously described) on plasticized films aged 2 weeks at 70°C. in an air-circulating oven and on unaged films. The amount of plasticizer used and the percent change in tensile strength after aging are given in Table VII. Plus values indicate an increase in tensile strength and minus values a decrease.

The change in tensile strength is associated with the volatility of the plasticizer. 2-Biphenylyl diphenyl phosphate, tricresyl phosphate, and the polyester gave the most heat-stable films.

(c) *Low-Temperature Flexibility.* The low-tempera-

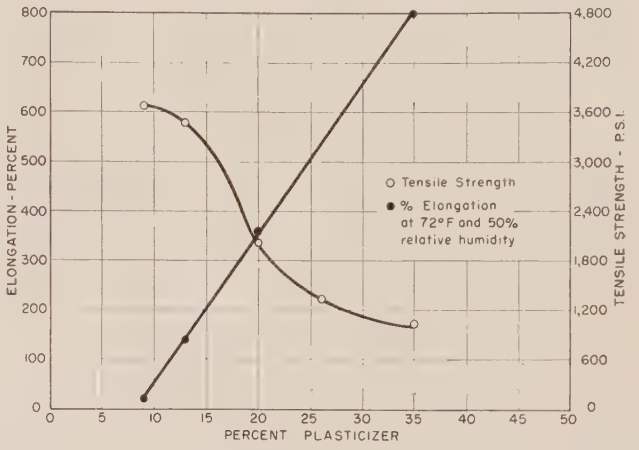
ELONGATION - PERCENT
TENSILE STRENGTH - P.S.I.
PERCENT PLASTICIZER
O Tensile Strength
● % Elongation at 72°F and 50% relative humidity

Fig. 10. The plasticization of the latex with Santicizer 141

ture flexibility of plasticized latex films was determined on films 2 mils thick stored in a cold box for at least an hour. The temperature of the cold box was lowered in steps. The flexibility of the films was evaluated by creasing them sharply. In Table VII the higher temperature indicates the temperature at which the films were still flexible, the lower indicates the temperature at which they became brittle.

Dibutyl sebacate imparts the best low-temperature flexibility to the film of all the plasticizers tested.

PAPER COATING

Coating Methods

Dow Latex 744-B coatings may be applied by any of the several methods now being used by paper coaters for water based coatings such as air knife coaters, brush coaters, roll coaters, and knife or doctor coaters. The type of coater used depends on the viscosity of the coating color, the speed of coating desired, whether a one or two-sided coating is desired, and the type of

Table VI. Chemical Resistance of Plasticized Latex Coatings

Test reagents	*Esterified coconut oil rating*[a]	*Di-2-ethylhexyl adipate rating*[a]
Nitric acid (3 *N*)	1	3
Sodium carbonate (7%)	1	2
Iron chloride (42%)	1	1
Soap (5%)	1	3
Hydrochloric acid (3 *N*)	1	1
Sodium hypochlorite (5%)	1	3
Mineral oil	1	1
Peanut oil	1	1
Aliphatic solvent (BP 97–113°)	1	3
Caustic (50%)	2	1
Hydrochloric acid (conc.)	3	2
Nitric acid (conc.)	3	3–4
Caustic (10%)	3	3
Acetic acid (3 *N*)	3	3
Acetic acid (glacial)	3	4
Carbon tetrachloride	4	3
Ethylene dibromide	4	4
Aniline	4	4
Ortho-dichlorobenzene	4	4
Dioxane	4	4

[a] Rating: (1) no change. (2) slight change. (3) some change. (4) severe change.

Table VII. Other Properties of Latex Films

Plasticizer	Fadeometer stability: Per cent in film	Fadeometer stability: Hours to failure	Heat stability, 2 weeks: Per cent in film	Heat stability, 2 weeks: Per cent change in tensile strength, %	Low temperature flexibility: Per cent in film	Low temperature flexibility: Becomes brittle at °C.
Dibutyl sebacate	13	1415	10	+150	10	−45 to −55
Dioctyl phthalate	13	1715	15	+24	15	−32 to −35
2-Biphenylyl diphenyl phosphate	..	..	25	−1	25	>15
A polyester	13	1390	20	+4	20	−15 to −32
Dibutyoxyethylphthalate	13	675	..	..	..	..
Alkyl arylphosphate	13	1445	15	+38	15	−32 to −35
Tricresyl phosphate	13	395	22	−1	22	−15 to −32

finish desired. If calendering, embossing, or polishing is done, less attention must be directed toward using a coater that gives a smooth finish. Where pinhole-free coatings are desired, coating methods that produce

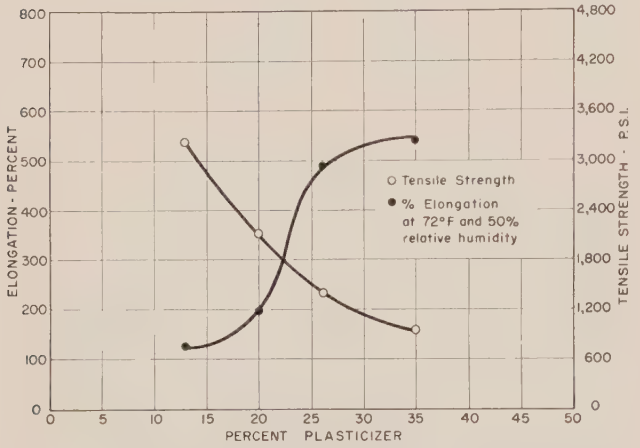
ELONGATION - PERCENT
TENSILE STRENGTH - P.S.I.
PERCENT PLASTICIZER
O Tensile Strength
● % Elongation at 72°F and 50% relative humidity

Fig. 11. The plasticization of the latex with Glyptal 2557

foam in the composition should be avoided. Due to the low surface tension of the latex and the viscosity of the coating color, it is sometimes difficult to remove foam from the coating color by the addition of antifoamers.

Base Papers

The properties of the latex coating are largely determined by the porosity and smoothness of the base paper. Very porous sheets cause instability of the coating composition and give a noncontinuous coating. High density, sized, coated, or otherwise nonporous sheets all help to give continuous coatings that bring out the true properties of the vinyl chloride–vinylidene chloride copolymer.

If special precautions are not taken, porous sheets may cause plating out of latex coatings on laboratory equipment. It is believed that quick penetration of the water in the coating into the sheet causes premature coagulation of the composition. This effect can be minimized (1) by using efficient stabilizers, such as casein; (2) by using easily emulsified plasticizers; (3) by aging the latex-plasticizer emulsions; (4) by increasing the coating rate; and (5) by using a less porous sheet.

On a rough, unsized kraft it was necessary to apply a 40 pound per TAPPI ream coating to obtain a pinhole-free coating. When a size coating of clay, casein, and a styrene-butadiene latex was used on the kraft to fill the pores and coat the raised fibers, a 20-pound coating gave a pinhole-free film.

Anything that stabilizes the emulsion, slows up the loss of water, or speeds up the rate of fusion of the latex particles aids in giving pinhole-free coatings.

Clear Coatings

A typical plasticized latex clear coating is listed below:

Ingredients	Parts by weight
Latex solids	75–85
Plasticizer	15–25
Thickener and stabilizer	0.5–1.5
Per cent nonvolatile in water	40–60

The amount of thickener is determined by the coating method used.

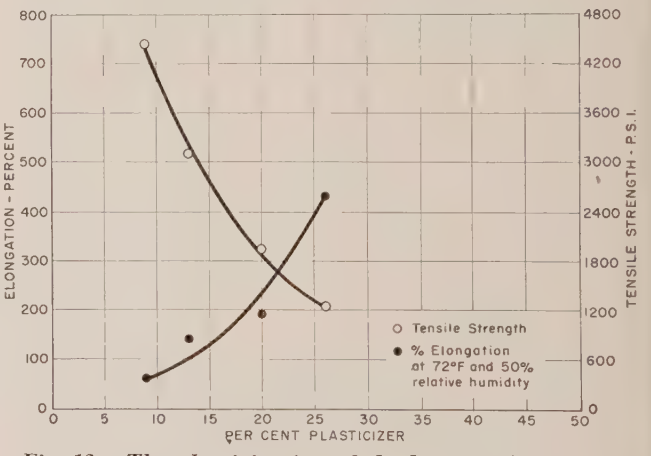
ELONGATION - PERCENT
TENSILE STRENGTH - P.S.I.
PER CENT PLASTICIZER
O Tensile Strength
● % Elongation at 72°F and 50% relative humidity

Fig. 12. The plasticization of the latex with Kronisol

As with free films, the choice of plasticizer depends on the particular properties desired.

Table VIII. Moisture-Vapor Transmission Rate of Plasticized Latex Coatings

Composition of the coating: Parts latex solids	Parts alkyl arylphosphate	Parts diethylene glycol monoethyl ether acetate	Parts paraffin wax emulsion solids	Parts methylcellulose 15 cp.	Parts sodium polyacrylate	Properties of coatings: Coating weight, lb./TAPPI ream	Grams per 100 sq. in./24 hr.
85	15	..	..	0.74	...	29.7	3.77
90	..	10	..	0.90	...	26.6	3.50
80	..	20	..	0.90	...	30.0	1.87
70	..	30	..	0.90	...	30.0	1.92
85	15	..	5	0.85	...	30.8	2.62
85	15	..	10	0.64	...	27.8	3.64
80	..	20	5	..	1.5	28.4	1.27
80	..	20	25	..	2.0	26.2	3.10
70	..	30	5	..	1.5	24.4	1.88

Moisture-Vapor Transmission

Some of the more important variables that affect the moisture-vapor transmission of clear coated papers are: (1) type and quantity of plasticizer, (2) waxes, (3) coating weight, (4) porosity of the base stock, (5) number of coats, and (6) stabilizer used.

In Table VIII are listed the moisture-vapor transmissions of double-coated papers dried at 100°C. between coats. The type of plasticizer, amount of plasticizer, and the effect of wax were the chief variables evaluated.

Diethylene glycol monoethyl ether, a nonpermanent type plasticizer, gave lower moisture-vapor transmissions than the alkyl arylphosphate, a permanent type. Twenty per cent of the acetate gave the lowest moisture vapor transmission. A larger amount showed no improvement. Five per cent of wax in the film gave lower moisture-vapor transmissions than 25%.

Grease Resistance

Two types of failure have been encountered when evaluating the grease resistance of clear coated papers: (1) pinhole failure and (2) staining.

Turpentine containing an oil-soluble dye effectively locates pinholes. A pinhole-free double coating containing 20 parts of diethylene glycol monoethyl ether acetate to 80 parts of latex[1] on a bleached sulphite sheet resisted the transudation of dyed turpentine for 35 minutes. After this time the test was discontinued because there was no penetration to the back of the sheet. The surface of the coating was stained slightly.

Lard containing the same dye was placed on the same sheet for 24 hours. When the lard was removed with a rag, there was no evidence of transudation or pinholes. There was a very slight staining of the surface.

Plasticizers affect the staining of the coating. Using dyed lard as the grease, pinhole-free coatings containing 30% of a modified polyacrylate latex, an acrylic polymer, were not stained after 25 minutes, whereas coatings containing 12.5% triethylene glycol di-2-ethylbutyrate, an ester of triethylene glycol, were stained slightly.

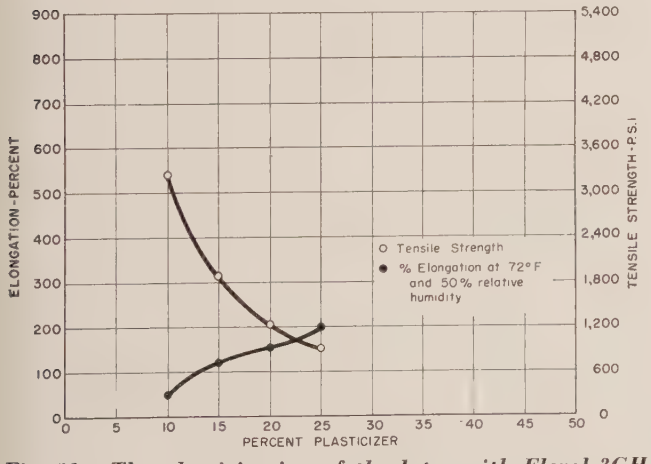

Fig. 13. The plasticization of the latex with Flexol 3GH

Water Resistance

The water resistance of latex-coated papers is fair when diethylene glycol monoethyl ether acetate is used as a plasticizer. It is felt that the highly active wetting agents facilitate penetration of the sheet. A double-coat system improves the water resistance due to elimination of pinholes. The effect of different plasticizers and waxes has not been investigated.

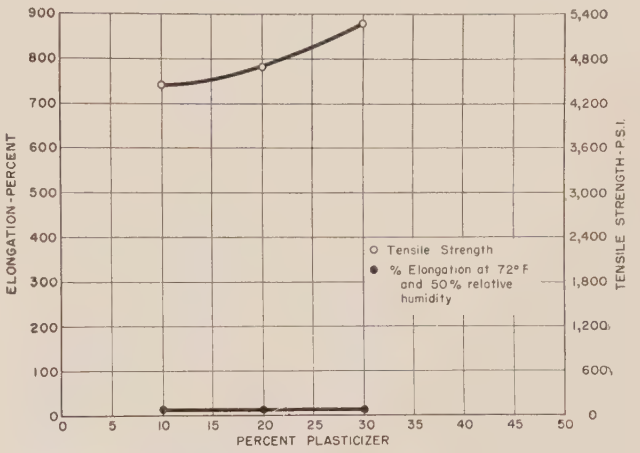

Fig. 14. The plasticization of the latex with carbitol acetate

Gloss

The gloss of the final coating is dependent on the plasticizer, the aging of the plasticizer-polymer emulsion, the thickener, and the base paper used. Although the smoothness and continuity of the base paper are important factors, improved gloss can generally be obtained by proper formulation of the coating composition. The efficiency of the plasticizer is very important. With inefficient plasticizers it is necessary to age the plasticizer-polymer emulsion for several days at normal room temperatures in order to obtain glossy coatings. This aging period may be shortened to hours by heating the coating composition at 50 to 60°C. The heating or aging period is not required for efficient plasticizers but it may be effective with some formulations. The thickener has a definite effect on gloss with a given plasticizer-latex composition. In the laboratory highest gloss has been obtained with a sodium salt of polyacrylic acid.

When a nonpermanent plasticizer such as diethylene glycol monoethyl ether acetate is used, higher gloss and less hazy films are obtained with smaller amounts of the acetate than with larger amounts. These facts are contrary to the belief that better films are glossier and less hazy. It may be caused by the acetate evaporating from the film after the water has completely evaporated.

Odor

Plasticizer-free coatings of the latex are odorless. Plasticizers may add odor depending on the type and quantity of plasticizer used.

Heat-Sealing Properties

Papers coated with plasticized and unplasticized latex can be heat-sealed readily. In Table IX are listed the temperatures at which full tearing bonds were obtained for coatings containing no plasticizer[2] and

[1] The same paper described in Table VIII.

[2] Coatings were prepared using nonpermanent diethylene glycol monoethyl ether acetate.

15% of an alkyl arylphosphate. The data were obtained with an electrically heated bar sealer using a dwell time of 1 second.

It will be noted that the face-to-face sealing temperature of the unplasticized coating is higher than the face-to-back temperature. This may be due to a thin coating of wetting agent that prevents intermixing of the two polymer faces in the face-to-face seal but helps the polymer penetrate into the sheet in the face-to-back seal.

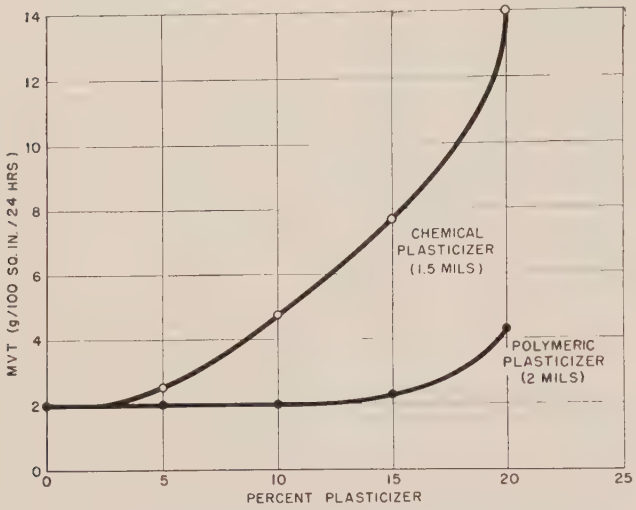

Fig. 15. The moisture vapor transmission rate of plasticized latex films

Light Stability

The light stability of latex coated papers has not been checked but it is presumed the performance would be comparable to the light stability of the free films if a light-stable paper is used as the coating base stock.

Pigmented Coatings

Pigments may be added to plasticized latex coatings to give (1) opacity, (2) low cost, (3) decorative effect, and (4) dullness to the coating. Water-dispersible pigments and pigments dispersed with complex sodium phosphates are readily dispersed in the latex coating compositions. Pigments that are alkali sensitive or contain soluble polyvalent cations, e.g., calcium, magnesium, iron, aluminum, etc., should be avoided.

When the amount of pigment is increased the grease resistance goes down because of a decrease in film continuity. The grease resistance of a coating containing 15 parts of an alkyl arylphosphate to 85 parts of latex solids mixed with clay in two ratios—1:1 and 1:2 clay to binder—was checked with dyed lard. The 1:1 clay to binder composition allowed transudation of the lard in 8 to 24 hours. The 1:2 clay to binder coating allowed no transudation of lard but showed considerable staining of the coating.

The work which has been done to date indicates that the latex is not an efficient pigment binder in the proportions of adhesive normally used for clay in the manufacture of coated printing papers.

USES

The basic properties of this vinyl chloride–vinylidene chloride latex indicate its suitability for a variety of uses. It is compatible with a wide range of modifying materials. It may be readily modified to form useful films. It is mechanically stable so that formulations comprising it may be used on most standard types of coating equipment.

Properly formulated coatings are color stable, nontacky, and tough. They are suitable for stain resistant decorative coatings, leatherette coatings, book cover papers, paper tape release coatings, and wallpaper overcoatings. Moderate moisture-vapor resistance, grease resistance, and heat sealability are properties of interest for industrial and food packaging papers.

Table IX. Heat Sealing of Latex Coated Paper

	Unplasticized		*Plasticized*	
	Face to face	*Face to back*	*Face to face*	*Face to back*
Temperature for full tearing bond, °F.	320	265	215	230

Most of these uses are well known. No elaborate discussion is necessary. A new field that is developing rapidly is the coating and sizing of paper to supply the base for a functional coating of vinyl lacquer, organosol, or plastisol. Such papers are becoming increasingly important in the manufacture of containers, floor coverings, and wall coverings. Conventional sizings and base coatings do not adhere well to the functional vinyl top coat. This vinyl chloride–vinylidene chloride latex is ideally suited for such coatings. Other vinyl systems adhere to it very well. Since it is a water system it may be readily adapted to paper mill operations, permitting the paper manufacturer to offer the paper converters a partially converted product with superior properties.

Where this latex is to be used as the barrier film on paper, it will normally replace a solvent or hot melt coating. Neither of these coating systems markedly affect the paper fibers. Latices, however, contribute large quantities of water to the surface paper fibers. Much remains to be learned about controlling the paper surface for depositing functional latex coatings.

A few methods have already been developed, but they involve covering the surface. Such methods may be economical where it is impractical to consider making changes in the paper manufacturing process. In general, however, the extra coating procedure is expensive unless it can be done on the paper machine itself. Synthetic latices promise to be the most inexpensive source of tough, functional coating resins. It is the responsibility of the paper technologist to find ways of tailoring paper to serve as a neutral surface that will permit the most efficient use of coating latices.

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Received May 15, 1951. Presented at the annual meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 19–22, 1951.

Pink Slime in Paper Mills

Control and Identification of Certain Causative Organisms

JOHN W. APPLING, N. JEAN RIDENOUR, and STANLEY J. BUCKMAN

Pink slime is of unusual importance in some paper mills because it is a difficult slime to eliminate and also because it produces undesirable pink spots in white paper. The authors have studied a group of seven pink slimes which originated in six fourdrinier paper machine systems and in one top white liner vat system of a cylinder machine. The objective of this study was twofold: first, to isolate and identify the pigment-producing organisms in pink slimes; and second, to learn how to control these more efficiently. Thus far, the authors have isolated the pigment-producing species of organisms from three pink slimes which came from three fourdrinier systems. Three species of bacteria were found repeatedly in these slimes and they have been identified as: *Alcaligenes viscosus*, *Bacillus subtilis*, and *Flavobacterium marinum*. The last-named species belongs to a genus which is characterized, in part, by yellow colonies. A surprising discovery, however, was that all isolates resembling either *Alcaligenes viscosus* or *Bacillus subtilis* readily produced pink pigment when grown on a potato infusion agar at a pH of 6.1. In order to study the control of these pigment-producing bacteria, percentage kills were determined in a pulp substrate. The results of these tests and other work suggest that neither individual cells nor small aggregates of these organisms offer any unusual resistance to commonly employed slime control agents. Thus, the effective control of such organisms must be directed at thick films and relatively large masses of these organisms. Thorough cleaning of the mill system by washing and scraping accessible surfaces followed by spraying these surfaces with BSM-11 or Butrol has been found effective. When the infection is present in locations which are not readily accessible, the circulation of a hot toxicant-detergent solution throughout the system for several hours has been found preferable, particularly when followed by the spraying of accessible surfaces.

Paper mill slime is usually described by listing some of its more obvious physical characteristics. A slime may be stringy, pasty, rubber, tapiocalike, hard, or horny. It may have some characteristic odor quite unlike that of the stock with which it is mixed and it may contain distinctly varicolored masses. None of these properties indicate with certainty what microorganisms, if any, really cause a particular slime. A careful search of the literature on the microflora of paper mill slimes showed that a considerable number of pigment-producing microorganisms have been isolated and identified; however, their correlation with a particular type of colored slime has seldom been indicated. In the case of pink slimes, Holmes (*4*, *5*) and Sanborn (*8*) stated that yeasts or yeastlike fungi were often the cause.

During the month of March 1950, the authors were consulted regarding the sporadic appearance of small pink spots in 100% bleached sulphite paper. This trouble had occurred on one of several fourdrinier machines during the early part of 1949 and again on a different machine in March 1950. This mill submitted samples of paper with pink spots and pink slime which had been taken from a beater apron. The slime developed on the apron surface where it contacted the stock. The usual direct microscopic examination and culturing on agar media revealed the presence of peculiar, wrinkled, tough, pink-colored colonies on malt agar after 5 days of incubation at 28°C. The pink pigment developed slowly and it disappeared as the culture aged. The pink growth was peculiar in that it was extremely difficult to separate small pieces from it. These same characteristics were also noted in the original pink slime.

Stimulated by these observations and by prior work on problems caused by pink slime in a number of paper mills, the authors initiated an intensive study of this problem. The objective was twofold, namely, to isolate and identify the pigment-producing organisms in various pink slimes and to learn how to control these more efficiently. Since March 1950, the authors have received seven samples of pink slimes which originated in six fourdrinier machine systems and in one cylinder machine system. A fairly complete history for each slime was obtained from a competent person in each mill in response to a questionnaire provided for this purpose.

ISOLATION OF PIGMENT-PRODUCING ORGANISMS

From preliminary observations it appeared logical to limit the work of identification and control to those pure cultures of pigment-producing bacteria which could be isolated on suitable agar media. Microscopic examination of a composite sample from different appearing masses of slime is recognized as a useful method to differentiate between microfloras with regard to whether capsulated bacteria or molds predominate in the original slime. This method involves the preparation of at least one wet mount, an India ink smear, and a simple stained smear for each slime. Its usefulness is limited to a rapid proximate diagnosis which can only indicate whether a slime is predominantly composed of capsulated bacteria or molds or whether both types are present. Obviously the microscopic examination cannot reveal much concerning the ultimate identity of the slime-forming microorganisms. It is then necessary to use cultural methods. For this pure cultures must be isolated on a suitable medium.

As previously stated, malt agar seemed suitable for the initial development of peculiar, wrinkled, tough, pink-colored colonies from one pink slime, but the pigment did not develop on subsequent transfers. Since

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a superior medium was desired, four pink slimes were streaked on various agar media. A potato infusion agar* proved to be superior to all others which were tried. A study of the effect of temperature and pH upon pigmentation was also undertaken at this time in order to determine what conditions were optimum for the isolation work. It was found that either 28 or 37°C. was excellent; also that the optimum pH range was from 5.5 to 6.5. It was decided, on the basis of more incubator space at 28°C., to use this temperature. The pH of the potato infusion agar as prepared was 6.1. The incubation period varied from 4 to 7 days.

In requesting pink slime samples for this work, the authors specified that they be refrigerated overnight and that they be placed in refrigerated thermos bottles. The refrigerated samples were then shipped to Memphis by air mail. This procedure was adopted to maintain the biological sample in as nearly its original condition as possible. Upon arrival at the laboratory, the sample was promptly prepared for streaking on freshly poured potato infusion agar plates. A portion of the sample was also examined microscopically as described earlier. Incubation of streaked plates usually resulted in the development of pigmented growth, which was picked and restreaked on potato infusion agar. This process was continued until it became evident that a pure culture of each pigment-producing species had resulted. Because of the slow development of some pink pigment-producing species, it was necessary to wait as long as a week before subculturing; however, this resulted in very tough growth which made subculturing both difficult and slow. This procedure has been followed on each of seven pink slime samples. In some instances better results were obtained by diluting the culture in broth followed by streaking the highest dilution which gave growth. Although only three of the samples have been completed, the pure cultures obtained have proved to be of unusual interest.

It is beyond the scope of this article to describe the characteristics of the pure cultures obtained. It should be stated that Skerman's key (*9*) for the identification of genera was used first and then Bergey's Manual (*3*) for the identification of the species. Three different species of pigment-producing bacteria are being reported at this time. The names of these species and the characteristics of their growth on potato infusion agar at the pH of 6.1 are as follows:

1. *Alcaligenes viscosus* develops slowly, first into smooth yellowish-colored colonies which change into wrinkled, tough, pink-colored ones. The pigment does not diffuse into the agar.
2. *Bacillus subtilis* develops rapidly into rather tough, membranous, pink-colored colonies from which part of the pigment diffuses into the agar.
3. *Flavobacterium marinum* develops rapidly into smooth, yellow colonies. The pigment does not diffuse into the agar.

The presence of the genus *Flavobacterium* in paper mill slime has been reported by Nason, Shumard, and Fleming (*7*); by Smith (*10*) who mentioned the species *Flavobacterium synxanthum* and *Flavobacterium aurantiacum;* by Holmes (*4*), and by Sanborn (*8*) who mentioned the species *Flavobacterium turcosum, Flavobacterium aurantiacum,* and *Flavobacterium fecale.* As the generic name *Flavobacterium* indicates, the bacteria of this genus produce a yellow pigment. The species *Flavobacterium marinum* isolated by the authors from pink slimes has not been reported previously as a species found in paper mill slime.

The species *Alcaligenes viscosus* and *Bacillus subtilis* have been reported in the microflora of paper mill slimes by Smith (*10*) and Sanborn (*8*). The second species has also been reported by Nason, Shumard, and Fleming (*7*) and by Holmes (*4*). The probable important part played by these two species in the production of pink slime has never been reported. The authors believe that a previously undescribed property of *Bacillus subtilis* has been observed. The American Type Culture Collection 6051 strain of *Bacillus subtilis* readily produced the same growth with pink pigment on potato infusion agar which was observed repeatedly for the *Bacillus subtilis* isolates from pink slimes.

Similarly in the case of the species identified as *Alcaligenes viscosus,* the production of pink pigment on potato infusion agar has not been given as a characteristic for this species. For the isolates from pink slime the ability to form pink pigment on potato infusion agar seemed to decrease as the number of transfers increased. In the case of one isolate, only very slight pink pigment formed after about 3 months of frequent transfers. It would seem that the isolate from pink slimes might be a pink variety of *Alcaligenes viscosus,* since the ATCC 9036 strain of *Alcaligenes viscosus* produced only the first phase of pigmentation on potato infusion agar, namely, the production of smooth, yellowish-colored colonies. No change from yellow to pink occurred.

RESISTANCE OF PINK VARIANT OF *ALCALIGENES VISCOSUS* TO TOXICANTS

Earlier in this article it was stated that pink slimes present a serious even though sporadic problem in causing small pink spots in finished white papers. It seemed highly desirable, therefore, to study the effect of various toxicants upon one or more of the pigment-producing organisms from pink slime. Since the colonies of the pink variant of *Alcaligenes viscosus* and the masses of pink slime from which it was isolated were so remarkably similar, it was decided to employ this variant as the first test organism and isolate 6 was selected for this purpose. Incidentally, the pink slime from which this isolate was obtained came from the mill to which reference was made at the beginning of this article. This pink variant was isolated from two pink slimes received about 2 months apart from the same mill.

The toxicants selected for this phase of the study were: (1) phenylmercuric acetate (recrystallized); (2) potassium 2,4,6 trichlorophenate (technical grade); (3) sodium pentachlorophenate (technical grade); (4) BSM-11, which contains a mixture of phenylmercuric acetate and potassium 2,4,6 trichlorophenate; and (5) Butrol, which contains a mixture of phenylmercuric acetate, and potassium orthophenylphenate.

The authors employed the pulp substrate test method which has been in use at Buckman Laboratories, Inc., for approximately 5 years. Since this test method has

* Formula used contained the following: infusion from 250 grams of potatoes; bacto nutrient agar, 23 grams; bacto dextrose, 10 grams; sodium chloride, 5 grams; distilled water to complete 1000 ml. The potatoes were boiled in water until well cooked and then disintegrated in a Waring blendor. No adjustment of the pH was necessary.

not been published previously, it is given in the appendix. With the objective of determining the bactericidal effect of a toxicant in an environment simulating that of the paper mill system, a suspension of spruce groundwood pulp was employed as the substrate to which rosin, alum, toxicant, and test organism were added. By means of this method the number of colonies was determined which represented those surviving a contact period of 2 hours to each of a series of concentrations of toxicant in a groundwood pulp substrate.

TABLE I

Percentage kills of isolate 6 (pink variant of *Alcaligenes viscosus*) by phenylmercuric acetate, potassium 2,4,6 trichlorophenate, sodium pentachlorophenate, BSM-11 and Butrol. Pulp substrate method used and plates incubated at 28°C. for 72 and 96 hours.

Toxicant	*Concn., p.p.m.*	*Percentage kills obtained on* 9/28/50	10/4/50
Phenylmercuric acetate	0.1	0	0
	0.3	0	19
	0.5	57	39
	0.7	84	70
	1.0	99.8	94
Potassium 2,4,6 trichlorophenate	20	27	0
	40	68	44
	60	98	95
	80	99.5	99.4
	100	99.9	99.9
Sodium pentachlorophenate	20	5	4
	40	80	68
	60	99.8	99.8
	80	99.9	100
	100	100	100
BSM-11	2	37	47
	4	90	94
	6	99.8	99.7
	8	99.9	99.9
	10	100	100
Butrol	2	43	39
	4	86	84
	6	99.6	99.5
	8	99.9	99.7
	10	99.9	99.9

Various runs were made to determine and recheck the values for percentage kills of isolate 6 by the five toxicants listed. Table I summarizes the percentage kills which were obtained in two typical runs started on September 28 and October 4, 1950. Because of slow growth of the test organism, the plates were incubated either 72 or 96 hours at 28°C. before colony counts were made. For the evaluation of data to compare one toxicant with another, the authors usually employ the concentrations which kill 80% of the test organism. This value, which is commonly designated as the LD_{80} value, can be determined from Table I. In the case of phenylmercuric acetate, the LD_{80} value for the September 28 run fell between 0.5 and 0.7 p.p.m. which would be approximately 0.6 p.p.m., whereas for the October 4 run it fell between 0.7 and 1.0 p.p.m. or approximately 0.85 p.p.m. The average LD_{80} was 0.7 p.p.m. Similarly, the LD_{80} averages for potassium 2,4,6 trichlorophenate, sodium pentachlorophenate, BSM-11, and Butrol were 50, 50, 3, and 3 p.p.m., respectively.

One way of comparing under laboratory conditions the resistance of different organisms to a particular toxicant is to determine the LD_{80} values of this toxicant for each organism. This has been done in many cases of mixed microfloras as well as pure cultures. Of special interest in connection with isolate 6 has been a comparison of its resistance with that of *Aerobacter aerogenes*. Since pink slime has been difficult to control in some mills, it might be suspected to contain some unusually resistant microorganisms. Using *Aerobacter aerogenes* as the test organism, the average LD_{80} values for phenylmercuric acetate and BSM-11 were 0.2 and 2 p.p.m., respectively. The corresponding values for isolate 6 were 0.7 and 3 p.p.m. Thus the resistance of isolate 6 was somewhat greater than that of *Aerobacter aerogenes* but the difference was not a large one when proper consideration is given to the variation in results for determinations of this type.

The evidence, therefore, indicates that the resistance of pink slime to conventional daily treatment in the paper mill very likely is the result of a combination of factors. Two of the more apparent ones arise from the difficulty of exposing the individual organisms or small aggregates to the action of the toxicant in the mill system. Pink slime forms tough, impervious, adherent films on mill equipment, whereas isolate 6 from pink slime was well dispersed during its exposure to toxicants in the pulp substrate method. A second factor is that part of the pink slime frequently grows above the normal water or furnish level and thus is contacted by normal daily "slug" treatment only at infrequent intervals. In contrast, the agitation provided in the pulp substrate method insures continuous contact of well-dispersed bacteria with the toxicant.

CONTROL OF PINK SLIME IN PAPER MILL SYSTEMS

It was found in some mills experiencing trouble with pink slime that neither the usual "slug" nor the continuous addition of toxicants economically controlled pink slime or pink spots in paper which resulted from the slime. Buckman Laboratories, Inc., developed a successful method for controlling pink slime. The difficulties encountered in controlling this type of slime have had a major part in the decision to make a fundamental study of pink slime. However, this article would be of more academic than practical value if it did not include the practical control measures which have already proved their efficacy.

The method used by Buckman Laboratories, Inc., for controlling persistent accumulations of slime on the surface of wooden, concrete, or corroded metal headboxes, flat-box seal pits, white water chests, etc., consists of the direct application of a spray treatment with either BSM-11 or Butrol to these surfaces. Portable, hand-operated pressure-type industrial sprayers with all essential parts of stainless steel are available and have been found satisfactory for use in applying either toxicant. The surfaces to be sprayed are first cleaned thoroughly with a high-pressure hose supplemented by scraping and wire brushing, if necessary. The entire surface then is thoroughly wet with the toxicant applied in the form of a quite coarse spray and allowed to soak into the pores of the wood, concrete, or corroded metal surfaces. This results in killing many slime-forming organisms which are not reached by a conventional clean-up and remain to resume growth on the surfaces as well as contribute to the reinfection of the system as a whole. Spraying should be done as soon as possible after the shutdown to allow maximum time of contact before start of operations. Care should be taken not to spray the top edge of pits, tanks, or chests on which workmen may rest

their hands at various times during operations. It is adequate to spray the side walls to about 6 inches above the water line, assuming this is within 3 inches of the top of the pit, tank, or chest. In most cases, the spray treatment is not a replacement for a daily treatment program but it is a valuable supplement to slime control programs in general and particularly in the elimination of pink slime infections.

The workmen applying the spray of either BSM-11 or Butrol should be provided with rubber gloves and goggles. They also should be instructed to wash thoroughly and promptly with cool water and soap any area of skin contacted by either toxicant. Blistering of the skin will result from prolonged contact with either toxicant. Whenever a spray is applied inside a relatively closed tank or a large pit or chest, two men should be present and the man spraying should wear a mask with a type N (U. S. Bureau of Mines) canister. The second man should be present merely as a normal safety precaution and they should alternate spraying at 15 minute intervals.

When the pink slime is present in locations which are not readily accessible for the spray treatment, the circulation of a hot toxicant-detergent solution throughout the system for several hours has been found preferable, particularly when followed by the spraying of accessible surfaces as described in the preceding paragraphs.

The fundamental study of pink slime is being continued in combination with work of a comparable nature on other problems of industrial microorganism control.

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APPENDIX. PULP SUBSTRATE METHOD FOR DETERMINING THE RELATIVE EFFECTIVENESS OF TOXICANTS TO BACTERIA

The following procedure is recommended for the preliminary evaluation of different toxicants for slime control and is based on the determination of the minimum concentration which will result in 80% kill of a suitable test organism under the conditions described. It is recognized that the method does not evaluate all of the characteristics of toxicants which are of importance in mill use, such as the ability of the toxicants to concentrate in the white water of relatively closed systems. The method, as outlined, also is limited to tests of the toxicants against bacteria although molds and yeastlike organisms are known to be significant components of slime in pulp and paper mills. The results obtained from the use of the method should be regarded only as a preliminary guide in the selection of promising toxicants for use in trial runs in pulp and paper systems.

Because of the exacting technique required in bacteriological procedures, reproducible results can be secured only in the hands of a well-trained technician.

Apparatus and Equipment

1. *Balances.* One balance with a platform of a size to accommodate Petri dishes readily is suitable for use in the preparation of cultures employed in this test as well as other related bacteriological work. This balance should be sensitive to 0.1 gram. An analytical balance sensitive to 0.1 mg. should be employed for weighing the toxicants used in the preparation of stock solutions for the test.

2. *Bottles.* Pyrex glass milk dilution bottles, 180 ml., fitted either with screw caps or Escher rubber stoppers are used for water blanks and pulp cultures.

3. *Colony Counter.* Any one of several types may be used. The Quebec, the Buck, and the Wolffhuegel colony counters have been found satisfactory. A hand tally for recording the count is recommended.

4. *Cotton.* Rolls of nonabsorbent cotton are used for making plugs.

5. *Culture Tubes.* These are used for tubing medium and may be of any suitable size, such as 15 by 125 mm. or 18 by 150 mm. without lip and preferably of Pyrex glass.

6. *Disintegrators.* They may be either the electrical type, such as the Waring blendor (Waring Products Corp., 545 Fifth Ave., New York, N. Y.), and Bersted (Bersted Manufacturing Co., Fostoria, Ohio), or the ball-mill type.

7. *Flaming Equipment.* Depending upon the circumstances, an alcohol lamp or a Bunsen burner may be used to flame inoculating needles, mouths of sterile containers, etc.

8. *Flasks.* Erlenmeyer flasks, 250-ml., are used as containers for the medium.

9. *Incubators.* Reliable incubators which will maintain temperatures of 30 ± 1°C. and 37 ± 1°C. are necessary to provide proper incubation conditions for the inoculated bottles, flasks, tubes, and plates.

10. *Inoculating Needle.* A 24 B. & S. gage nichrome needle about 65 mm. in length with a suitable holder is recommended.

11. *Petri Dishes.* Pyrex Petri dishes 100 by 15 mm. are recommended for plating samples. They may be sterilized conveniently in corrosion-resistant metal boxes fitted with covers or wrapped in paper.

12. *pH Meter.* A good pH meter is needed for the range of 4 to 8.

13. *Pipets.* Three sizes of pipets are used, 1.1-ml. milk dilution type, and 1.0-ml. and 10-ml. graduated types in graduations of 0.1 ml. They may be sterilized conveniently in corrosion-resistant metal boxes or wrapped in paper.

14. *Sterilizers.* Two types are needed, the particular style and size depending upon the needs of each laboratory: (a) steam sterilizer, such as an autoclave or a pressure cooker; (b) hot-air oven. For most laboratories, electrically heated ovens are more satisfactory than those heated by gas, but the latter may be used if desired.

In both cases, thermometers are used to determine the temperature during sterilization.

Chemicals and Medium

1. *Alum.* National Formulary VI or U.S.P. aluminum sulphate ($Al_2(SO_4)_3 \cdot 18H_2O$) should be used. A 0.4% solution of the hydrated aluminum sulphate is prepared in distilled water and sterilized with compensation being made for any loss in weight during sterilization by the addition of sterile distilled water.

2. *Dilution Water.* Sterile distilled water should be used for all dilutions. Compensation should be made for any loss during sterilization by the addition of the proper volume of sterile distilled water.

3. *Pulp.* A suitable groundwood pulp is one produced when no toxicant has been used in the pulp system or in any white water being returned to the pulp system for a minimum period of 24 hours.

4. *Rosin Size.* Rosin size 70 D manufactured by the Papermakers' Chemical Department, Hercules Powder Co., Kalamazoo, Mich., is recommended. A 2% solution of rosin size should be prepared in freshly boiled, warm distilled water, sterilized, and compensation made for loss during sterilization by adding sterile distilled water.

5. *Standard Nutrient Medium.* Difco dehydrated nutrient agar is recommended. It also may be prepared from the ingredients according to the procedure outlined by the American Public Health Association (*1*). After the medium is dissolved, the hot mixture is placed in Erlenmeyer flasks, in dilution bottles, or in culture tubes, and plugged with cotton. It is then ready to be sterilized.

Sterilization of Equipment and Medium

Depending upon the nature of the equipment to be sterilized, one of two methods is followed:

1. Steam Heat (autoclaves and pressure cookers). The following are sterilized by heating for 20 minutes at a minimum of 121°C. (250°F.), corresponding to 15 p.s.i. steam pressure: alum solution, dilution water, nutrient agar medium, and rosin size solution.

2. Dry Heat (electrically or gas-heated ovens). The following are sterilized by heating for at least 2 hours at a minimum temperature of 165°C. (330°F.): Petri dishes and pipets.

Toxicant Solution

Prepare stock solutions of the toxicants in distilled water following any special instructions provided by the manufacturers. The concentration of the stock solution should be such that it will provide the desired range in concentration when 0.5 to 5.0 ml. are diluted to 50 grams in the pulp cultures. The following increments are recommended for different concentration ranges.

Test Organism

Obtain a suitable test organism, such as *Aerobacter aerogenes*, from the American Type Culture Collection, 2029 M Street, N. W., Washington 6, D. C., for use in the tests. Transfer the culture to tube slants of nutrient agar by adding 2 ml. of sterile distilled water to the original culture, dispersing the growth in the water with a pipet or needle and adding 0.05 ml. of the suspension to each of two tube slants. After incubation for 24 to 48 hours at 37°C., use one of the tube slants for the inoculation of a 250-ml. Erlenmeyer flask containing 20 grams of nutrient agar. Add 2 ml. of sterile water to the tube slant and disperse the growth in the water with a pipet or needle. Transfer approximately 0.5 ml. of water suspension to the surface of the agar in the flask and distribute it over the entire surface by tilting the flask. After inoculation, incubate the flask culture for 24 hours at 37°C. and use as the source of inoculum for the pulp cultures. The inoculum should be sufficient to provide between 1,000,000 and 2,000,000 colonies per ml. when 1 ml. is transferred from the pulp culture. To obtain this, transfer 10 ml. of sterile water from a 99-ml. water blank to the surface of the growth on the 24 hour flask culture, and disperse the growth throughout the water by swirling the flask. Transfer 1 ml. of the water suspension to the remaining 89 ml. of the sterile water blank and mix the contents of the bottle by shaking vigorously, using 20 complete cycles of vertical motion. Use 1-ml. portions of this suspension for the inoculation of each pulp culture.

The second tube slant of the test organism should be kept as a stock culture.

Range, p.p.m.	*Increment, p.p.m.*
0.02 to 0.1	0.02
0.1 to 1.0	0.1
1 to 10	1.0
10 to 50	2.0
50 to 100	5.0
Above 100	10.0

Pulp Cultures

Prepare a slurry of groundwood pulp by disintegrating 25 grams of air-dry groundwood pulp in 975 ml. of distilled water. The time required for complete disintegration will vary from about 5 to 20 minutes depending upon the disintegration equipment employed and the condition of the pulp. Dilute this slurry with one liter of distilled water and mix thoroughly by swirling 20 times. Weigh 40 ± 0.1-gram portions of the pulp suspension into each of the desired number of Pyrex glass milk dilution bottles. Use only a pulp suspension prepared the same day. Swirl the flask containing the suspension two times immediately prior to the transfer of each 40-gram portion. Stopper or cap and sterilize the series of bottles. After sterilization, allow the bottles to cool to approximately 30°C. and then weigh the bottles to the nearest 0.1 gram. Since the final portion of the test is to be run at 30°C., it is desirable to have the bottles as near this temperature as practicable throughout the test.

Because the time interval between the preparation of the suspension of the test organism for inoculating the bottles and the addition of the suspension to each bottle may have some effect on the resistance of the organism, it is desirable to arrange each series so that the concentration of toxicant does not increase or decrease regularly through the series but is randomized so that the effects of the differences in time are minimized. Moreover, if several toxicants are to be tested at the same time, the series involving these should be interlocked for the same reason. For example, the following arrangement may be used when two series of nine flasks each are tested in which the series are represented by the letters A and B and increasing amounts of toxicant in each series by the numbers 1 to 8: Control, A1, B1, A8, B8,

A2, B2, A7, B7, A3, B3, A6, B6, A4, B4, A5, B5, and final control.

Make the following additions aseptically to each bottle in the order named and shake vigorously after each addition, using 20 complete cycles of vertical motion:

1. The amount of sterile distilled water which is necessary to bring the total weight of the contents of the bottles to 50.0 grams after all other additions have been made.

2. One milliliter of sterile stock solution of rosin size. Add this at 1-minute intervals to the bottles. For example, to bottle no. 1 (control) at 10:00 a.m., to no. 2 (A1) at 10:01 a.m., to no. 3 (B1) at 10:02 a.m., etc., and finally to no. 18 (control) at 10:17 a.m.

3. The volume of stock solution of toxicant to give the desired concentration in parts per million. No toxicant is added to the controls but otherwise handle these bottles in the same manner. Space this operation at 1-minute intervals also; in the example, it would be done between 10:18 and 10:33 a.m.

4. The volume of sterile 0.4% alum solution necessary to provide a pH between 5.0 and 5.5 as determined by prior tests of pulp cultures prepared in the same manner with the same ingredients. Also make these additions with a 1-minute interval between bottles; in the example, from 10:34 to 10:51 a.m.

5. One milliliter of the aqueous suspension of the test organism. Prepare this suspension not more than 5 minutes before it is to be used. Again, space the additions 1 minute apart and allow 30 minutes between the addition of alum and the addition of the inoculum. In the example, the inoculum would be prepared at 10:59 a.m. and would be added to bottle no. 1 at 11:04 a.m. and to bottle no. 18 at 11:21 a.m.

After the final addition, remove the bottles to a room or incubator controlled at 30 ± 1°C. and allow to stand for 2.0 hours from the time of the inoculation of the first bottle.

Dilution, Plating, and Incubation

Dilute and plate the pulp cultures in a room which is relatively free of air currents and dust. About 30 minutes before starting these operations sponge the surface of the work table with a solution of a suitable toxicant, such as 0.05% phenylmercuric acetate.

The dilutions which should be plated will vary to some extent but 1:100, 1:1000, and 1:10,000 dilutions of each pulp culture should be adequate. In all cases, the aim should be to obtain plate counts in the range of 30 to 300 colonies per plate. In order to maintain the 2.0-hour interval for each pulp culture, it is necessary to plate at the rate of one pulp culture per minute. This requires two operators.

Operator 1. Start on the time schedule already determined. Shake bottle no. 1 vigorously, using 20 complete cycles of vertical motion. With a 1.1-ml. pipet, transfer 1 ml. from bottle no. 1 to a 99-ml. water blank and shake vigorously. Continue through the entire series of pulp cultures as rapidly as possible making only the 1:100 dilution.

Operator 2. Shake vigorously the 1:100 dilution from bottle no. 1. Using a 1.1-ml. pipet, transfer 0.1 and 1.0-ml. portions to sterile Petri dishes; also transfer 1.0 ml. to a second 99-ml. water blank. After shaking vigorously the 1:10,000 dilution, pipet 1 ml. to a Petri dish. Continue through the entire series with the assistance of operator 1 as soon as the latter has completed the 1:100 dilutions.

After all of the dilutions have been made, add to each plate about 15 ml. of standard nutrient agar cooled to approximately 45°C. (133°F.). Agitate the plates with a quick, short reciprocating motion to obtain an even distribution of the sample. In general, pour two control plates for each series using only dilution water, medium, and equipment from the lots prepared for the series.

After the plates have been agitated, place them on a flat surface until the medium solidifies; then invert and incubate the plated samples at 37 ± 1°C. for 48 ± 2 hours in an atmosphere practically saturated with moisture. Do not stack the plates too closely in the incubator.

Counting Plate Cultures

After incubation, examine the cultures for the presence and number of colonies by holding the plates against a dark background, indirectly lighted. Colony counters are especially desirable.

If any particles other than fibrous material are observed in the cultures which cannot be definitely identified as colonies they should be examined microscopically. Plates with spreading colonies should be counted if at all possible, otherwise they should be reported as spreading colonies. Examine the plates prepared with the same lot of dilution water, medium, and equipment and record the results.

Calculations of Results

Record the results of the counts in terms of colonies per milliliter in the pulp culture bottles and so that not more than two significant figures are used (*2*). For example, a colony count of 142 is recorded as 140 and one of 145 as 150. Base the calculations on the colony count per milliliter from the particular dilution which yielded between 30 and 300 colonies per plate, or the average count of the colonies per plate from two dilutions or two duplicate plates not within the range. Use the recorded number of colonies per milliliter for the control pulp culture and those containing different concentrations of the toxicant as the basis for calculations of the percentage kill obtained with each concentration of the toxicant.

For this determination use the following formula:

$$\frac{(\text{count for control}) - (\text{count for concentration of toxicant}) \times 100}{(\text{count for control})} = \text{percentage kill}$$

It is recommended that five series of concentrations of each toxicant be tested and the minimum concentration required to obtain an 80% kill estimated by the use of logarithmic-probability paper or use of a logarithmic-probit graph (*6*). When logarithmic-probability paper is used, the original data can be plotted directly to convert to a linear relationship between percentage kill and concentration. A straight line then can be fitted to the points and the concentration required to obtain 80% kill read directly. The concentration required to obtain any other percentage kill also can be read from the same straight line.

Received Feb. 22, 1951. Presented at the annual meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 19–22, 1951.

Microscopy and Identification of Synthetic Fibers

F. D. HOUGHTON

This paper presents the simple microscopy of the major synthetic fibers (viscose, acetate, and cuprammonium rayons, Nylon, Vinyon, Orlon, and glass) along with chemical and staining tests for confirmatory purposes. Other new fibers are omitted because of their infrequent occurence in the paper industry.

TODAY, as synthetic fibers* increase in use in the textile industry, the paper manufacturer finds himself more and more concerned with them in his business. Rag papermakers, of course, are particularly affected by some of the newer fibers used as raw materials, and some specialty paper manufacturers are including these fibers in their products. Until recently, however, the paper industry has not needed to pay much attention to them. As an example of this, TAPPI Standard T 401 m-42 is the only reference to synthetics with which we are familiar in the authoritative paper industry press, and that is only a brief paragraph referring the reader to an out-of-date British textile article of nine years ago. Most of the newer fibers have appeared since the time of publication of that article. It is in an attempt to remedy this situation that the present paper has been prepared.

Identification depends on observation of one or more distinctive properties of the unknown material. With such small individuals as fibers, the microscope plays an important part in this observation, but is not always essential. However, when samples are small, its advantages increase, since the small quantities required for analysis make a number of micro tests possible where only one macro test could be made otherwise.

In all qualitative analyses, and fiber identifications are no exception, it is good practice to check all results with a confirmatory test. Also, the confirmatory tests should be, if possible, of a different type than those which they are intended to confirm. The combination of a physical property, such as appearance, refractive index, or dimensions confirmed with a staining test is much better than two staining tests. The same characteristics that might affect one stain would be likely to affect the other, but the chances of them changing a physical property similarly are very slim. In our laboratory, final results are based on at least two different tests, and frequently more are employed.

Working continually with a limited number of fibers under the microscope, an experienced technician soon learns to recognize most of them almost on sight. However, there are some which are not easily distinguished, as most of you well know, even among the natural fibers. Many of the new synthetics are round in cross section and smooth on the exterior, without markings, making differentiation by visual examination almost impossible.

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* "Synthetic," for the purposes of this paper, is defined as any man-made fiber. The regenerated cellulosic rayons are not strictly synthetic, in that they are derived from a natural raw material, but to simplify the terminology are usually included by the trade in the "synthetic" category.

The average paper chemist or technician, however, does not have the time or opportunity to become thoroughly familiar with these newer materials, and hence is at a disadvantage when called upon to identify or separate fabrics containing them in the rag sorting department. Some types are seldom encountered, but others crop up frequently, especially in this age of blended fiber fabrics. A few simple staining and microscopical tests will answer most of the identification problems, but some will require further, more detailed, tests before characterization is complete.

The principal difference between natural and artificial fibers is their morphology, or external characteristics. Synthetic fibers are usually very uniform in diameter for their entire length as well as between fibers. Also, they usually run into longer lengths since they can be made in continuous filaments of indefinite extent. However, like their natural brethren, they have their structural differences.

Figure 1 shows very simply the principal physical characteristics of the more common synthetics. They are based on those drawn by J. M. Preston in the Sept., 1950, issue of the *Journal of the (British) Textile Institute.*

Viscose rayon (Fig. 2) which is the fiber most likely to be encountered, is the most abundant of all synthetic fibers. In 1949 the United States produced about 800 millions of pounds (with cupra), which is a substantial percentage of the total cotton production of about 4200 million pounds. Therefore, in mixed rags, one can expect to get about 19% viscose fibers. This fiber usually is identified by the striations running parallel

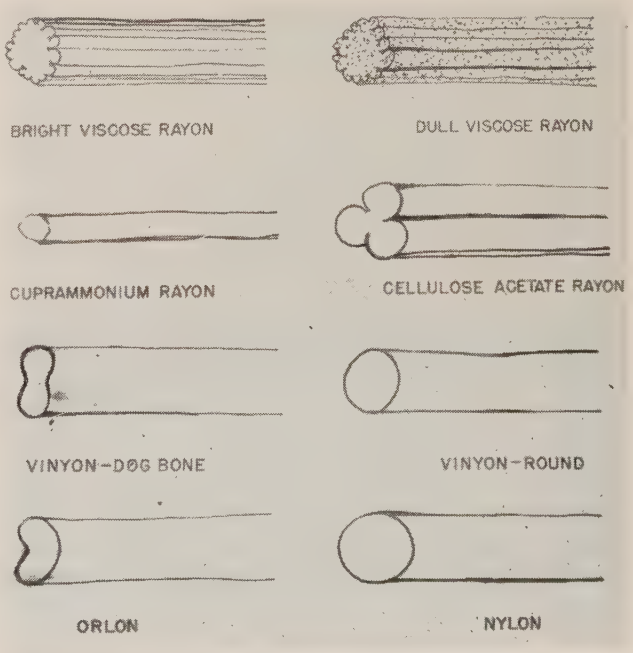


Fig. 1. Line drawings of fiber characteristics

Fig. 2. Viscose rayon—cross section and longitudinal view

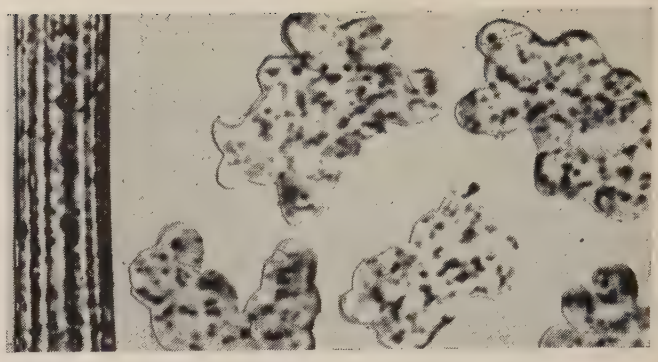


Fig. 4. Dull viscose—cross section and longitudinal view

to its axis, and which are actually irregular indentations in the surface as shown by the cross section. However, there are variations of this material, although they are not commonly encountered. An example of this is a foreign viscose fiber (Fig. 3), which is fairly smooth, having no striations. Delustered, or dull, viscose rayon (Fig. 4) is easily identified by the multitude of specks throughout the fibers. These are particles of titanium dioxide pigment which is one of the more commonly used materials in America for this purpose. Sometimes, however, they are delustered by application of a resin coating with the result that, under the microscope, the fibers appear to have a bad case of warts.

The diameter of viscose rayon fibers is not always the same. Several deniers, or diameters, are made from 1.0 to 20.0 and even higher. However, fiber deniers of 1 to 10 are most common, with 1.5, 3.0, and 5.5 the usual denier in commonly occurring fabrics. Denier, incidentally, is a textile term being the weight in grams of 9000 meters of a yarn or filament. For viscose rayon, 3.0 denier fibers have a diameter of about 20 mu. Denier varies with the density of the material. A light fiber having the same diameter as a heavy one would have the lower denier. Most synthetics in fiber form are made in various deniers in the above range. Fortisan, a regenerated cellulose acetate fiber, and cuprammonium rayon sometimes run less than 1.0 denier, while the protein fibers usually occur in the 20 to 100 denier range.

Cellulose acetate rayon, of which 320 millions of pounds are produced yearly (Fig. 5) ordinarily has a smoother surface, with fewer striations. However, some specimens resemble viscose closely, so differentiation, except by an experienced technician, should rely on chemical or staining methods.

Cuprammonium (Bemberg) rayon (Fig. 6) has a very smooth skin and is nearly round or polygonal in cross section, usually being of a finer denier than most other synthetics.

Vinyon (Figs. 7 and 8) is a thermoplastic vinyl chloride-acetate copolymer and is commonly listed as having a "dog-bone" cross section. Frequently, however, it is produced in a nearly round form. In the dog-bone shape it is readily recognizable either in the cross section or lengthwise, because of the bright line down the middle due to the thinner portion of the fiber.

Orlon, an acrylic fiber now being introduced on the market, and soon to be a major synthetic when its new production facilities are complete, presents a somewhat similar appearance to Vinyon, but it has more of a half moon effect. Under the electron microscope, the author has seen Orlon fibers laid flat on their backs, which appeared to be two fibers running parallel to each other because the central part was out of focus with the edges, and did not appear on the screen.

Nylon and glass are both circular in cross section and smooth of surface (Figs. 10 and 11).

For the microscopist who is going to have more than just an occasional contact with these materials, we suggest that a collection of small specimens, or prepared slides, of each of the fibers be obtained and used for comparison purposes. In fact such a collection is useful to anyone since it makes identification easier even for an inexperienced person. Most of this microscopical work is done at 100× or 200×. Cross sections are easily made by the use of a plate, the size of a microscope slide with holes about $^1/_{32}$ to $^1/_{64}$-inch in diameter. There are several on the market, Bausch and Lomb having one which is

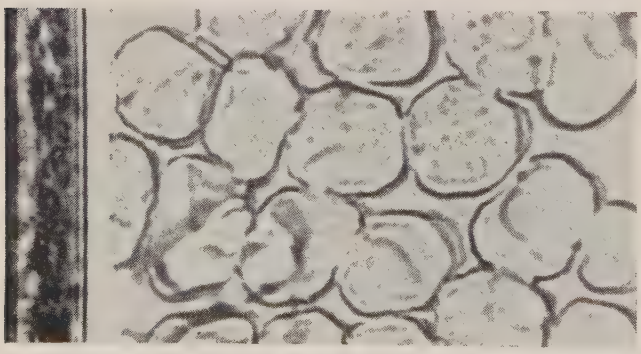


Fig. 3. Foreign viscose rayon—cross section and longitudinal view

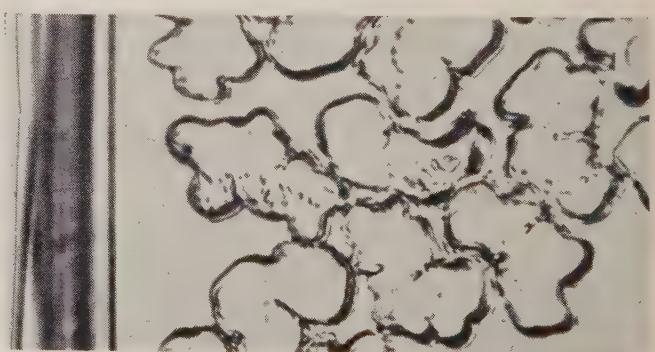


Fig. 5. Cellulose acetate—cross section and longitudinal view

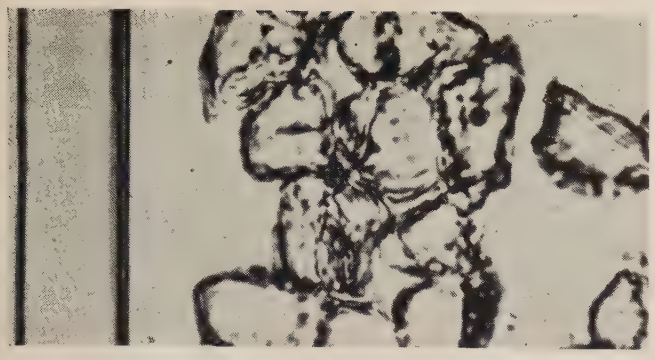


Fig. 6. Cuprammonium—cross section and longitudinal view

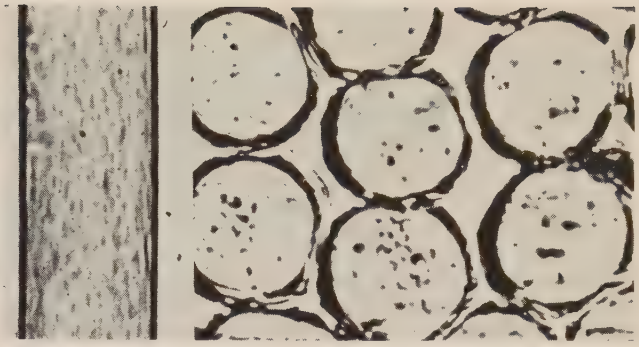


Fig. 8. Vinyon, round—cross section and longitudinal view

easily available at any laboratory supply house. A group of fibers or a yarn, usually doubled up, is pulled through a hole in the plate by means of a fine wire or very strong thread. When it is halfway through, both ends are clipped off with a razor blade, leaving them about $^1/_2$ mm. long. Collodion is then placed on both sides and allowed to set up completely, before slicing off even with the plate on both sides with a sharp razor blade. Although the cross section of the entire specimen is seldom perfect, there are always enough good cuts of fibers to show up the characteristics of the fiber. Other, more involved and expensive methods are available but are not considered practical for the average paper mill laboratory.

We have just seen how some fibers resemble each other so closely in appearance that positive identification may be difficult, so that other means of analysis are necessary. One of the simplest methods for characterizing Vinyon and cellulose acetate fibers is the use of organic solvents. A few fibers are placed on the slide dry, and are covered with a cover glass. This is usually done in the preliminary examination for appearance, so it does not consist of an extra operation. After the general inspection, if either of these materials is suspected, add a drop of acetone under the edge of the cover glass, while observing the fibers through the microscope. This solvent will rapidly dissolve out both Vinyon and cellulose acetate fibers, but will not touch any others. To determine which of these two are present, we have only to use a fresh sample and follow the same procedure with glacial acetic acid which dissolves only the acetate. Incidentally, both of these materials are sometimes delustered with titanium dioxide in the same manner as viscose rayon. However, the pigment is easily visible and does not have any effect on the results of the solvency tests.

Congo red stain applied to the specimen on a slide, and washed out to remove the excess color, will stain only cellulosic fibers and viscose (cellulose xanthate) coating that is sometimes used on paper. Viscose and cuprammonium rayons are the only synthetics that will be affected by this reagent.

The papermakers old standby, the Herzberg stain, is another good one for viscose, turning deep blue or violet on this fiber. This distinguishes it easily from acetate, which gives a yellow color, Vinyon, which does not stain, and of course, cotton, which turns wine red. The color obtained with viscose fibers is similar to that given by soda pulp, but there is no physical resemblance between the two, thus eliminating any confusion, even in a mixture.

Nylon is soluble at room temperature in either 90% phenol or concentrated hydrochloric acid. Since neither of these reagents attack Vinyon, the differentiation of these fibers is simple.

A simple test to apply to any fiber or fabric is a burning test. A small piece is ignited with a small flame and its burning characteristics and odor are noted. Table I gives a brief summary of these. As can be seen from this table, glass and asbestos are conveniently identified, the former because it melts and does not burn, and the latter because it is not affected at all.

There are a number of other stains, reagents, and methods for identifying the various synthetic fibers, and each one has its own merits. However, those presented have been chosen for their simplicity, and have been used in the author's laboratory. They will be sufficient for a large majority of the paper chemists'

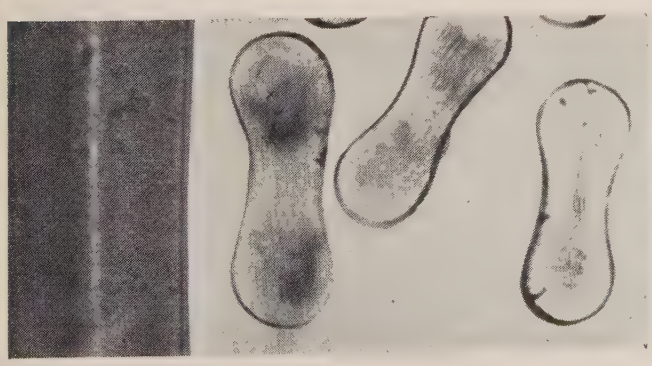


Fig. 7. Vinyon, dog-bone—cross section and longitudinal view

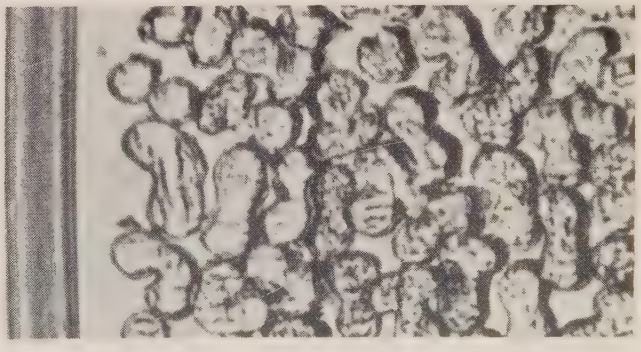


Fig. 9. Orlon—cross section and longitudinal view

Table I. Burning Test

Fiber	*Smell*	*Rate*	*Ash*
Animal (wool, silk, etc.)	Burnt hair	Slow	Hard and black
Vegetable (cotton, pulp, etc.)	Burnt paper	Rapid	Very little
Viscose and Cupra rayons	Burnt paper	Very rapid	Very little
Acetate rayon	Acetic acid	Slow	Hard and black
Vinyon	Paraffin or HCl	Slow	Irregular bead which shrinks from flame
Nylon	Amide, string bean	Slow	Glassy round bead which shrinks from flame
Glass	Melts but does not burn		
Asbestos	Is unaffected		

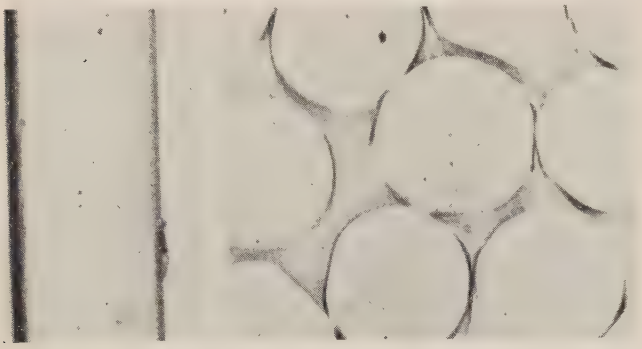


Fig. 10. Nylon—cross section and longitudinal view

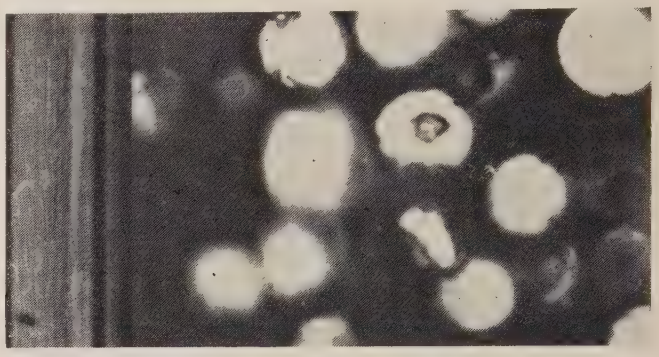
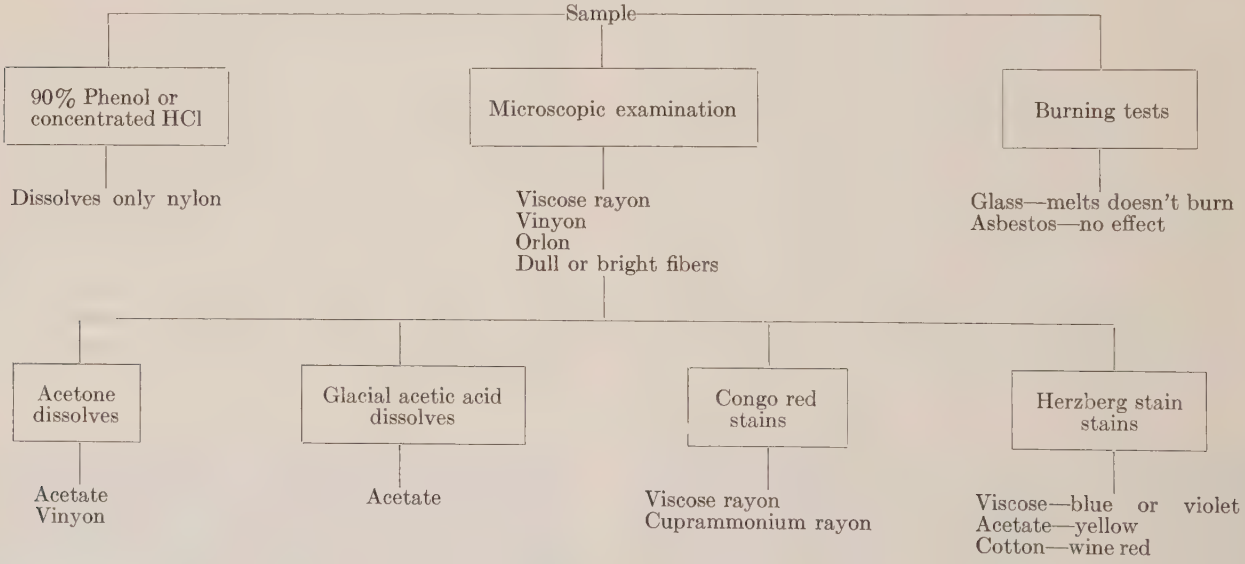


Fig. 11. Glass—cross section and longitudinal view

needs and are summarized in Table II which presents a systematic scheme for the carrying out of the tests described before. For special cases and unusual determinations, details can be found in a number of places. Chief among these are Mathews and Mauersberger's "Textile Fibers," the British *Journal of the Textile Institute* tentative standard for the "Identification of Textile Materials" published in March, 1948, and the ASTM tentative method D 276–43 T.

Many of the newer synthetic fibers have been purposely omitted from this paper because at present they are not sufficiently common to be encountered in ordinary work. However, it should be remembered that Chemstrand, Fiber V (Terylene), Fortisan, Saran, Caslen, Ardil, Vicara, Dynel, and many others are appearing in larger and larger volumes each year, and the paper chemist must keep them in mind when he is called upon to do an unusual identification job. The references above will supply most of the information needed to carry out such an analysis but some ingenuity may be needed in many cases. It will be well for the man who will meet up with such problems to start preparing himself beforehand.

Table II. Simplified Scheme for Fiber Identification



The photomicrographs and drawings were made by C. A. Martin of our Industrial Division Laboratory. Since most of the methods described in this paper are published in several places, and are widely known in the textile industry, it is almost impossible to give specific credit in each case.

Received Nov. 28, 1950. Presented at the Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 19–22, 1951.

Effect of Plasticizers on Some Physical Properties of Polymers

R. F. BOYER

A PLASTICIZER might be defined as an added material which decreases the accumulation of intermolecular forces along a polymer chain. Since the excellent physical properties of polymeric materials derived from an accumulation of small forces along the length of the polymer chain, it is evident that any added material which decreases these forces at regular intervals along the chain will serve to decrease tensile strength and softening temperature, and, in general, to affect all of the physical properties of the parent polymer.

It is now recognized that there are three different types of plasticizers, all of which accomplish this function of decreasing intermolecular forces in slightly different manners. The solvent-type plasticizer is one which is miscible with the polymer in all proportions. Its molecules are thoroughly dispersed throughout the polymeric system so that each individual plasticizer molecule is acting at a point, or within a small local region, defined by the Brownian motion of the plasticizer molecule. The nonsolvent type of plasticizer is one having only limited miscibility with the base polymer. In part, then, it will be dispersed, either as individual molecules or as clusters of molecules, and in part it will tend to exist as a separate phase consisting of extremely small droplets of plasticizer. The dispersed plasticizer will act in the same fashion as solvent-type plasticizer, whereas the small droplets will tend to disrupt forces between the polymer chains over quite large distances. Polymeric plasticizers are those whose molecular weights may vary from a few per cent up to 100% of that of the base polymer. They may or may not be compatible with the base polymer but they do constitute large continuous regions where the main polymer chains are separated from each other by this second constituent which in general is more flexible than the chains of the parent polymer.

In general, a plasticizer may be used in three different generally recognized ranges of concentration to affect different general types of properties. For example, up to 5% of the plasticizer may be added to decrease the melt viscosity of a plastic during fabrication. A heat-sensitive material such as Saran illustrates a case where this type of action is especially important. Ten per cent of the plasticizer may lower the melt viscosity in the fabricating range by as much as one order of magnitude, or it may reduce the fabricating temperature by 20 to 30°C. Secondly, plasticizers might be added in amounts up to 15 to 20% to effect the ordinary elasticity of a polymer and thereby to increase toughness or to modify some specific property of the polymer at room temperature. Finally, plasticizers may be added in amounts up to 25 to 50% to change the long-range elastic behavior of the parent polymer and thereby convert a rigid, brittle polymer such as polyvinylchloride into a rubberlike material so well known in the vinyl films.

Figure 1, using the data of Davies, Miller, and Busse on polyvinylchloride plasticized with tricresylphosphate, is a semilogarithmic plot of modulus of elasticity against per cent tricresylphosphate. It will be noted that the first 20% of plasticizer has relatively little effect on the modulus, whereupon the next 30% of plasticizer reduces the modulus by two orders of magnitude. The first 20% of plasticizer is affecting mainly the ordinary Hookian type of elasticity. However, this 20% of plasticizer has finally reduced the second-order transition from a value around 80°C. for the base polymer down to about 32°C. which is the temperature of measurement. For any further increments of plasticizer this system is now above its second-order transition and is therefore capable of exhibiting highly elastic behavior. The second-order transition temperature may be defined briefly as that temperature below which all polymers are hard and rigid and above which they show some measure of rubberlike or highly elastic behavior. Above the 20% of plasticizer the melt viscosity of the mixture has been decreased to a point where the plasticized polymer would exhibit continuous deformation under an applied load except for the fact that polyvinyl chloride appears to be slightly crystalline and these crystallites prevent long-range irreversible deformation. Polystyrene, by way of contrast, would show a similar modulus composition curve to that of Fig. 1, but would exhibit permanent deformation under load once sufficient plasticizer had been added to reduce the second-order transition temperature to around room temperature. Since polystyrene lacks crystallinity it does not form a commercially feasible plasticized system even though it can be plasticized with any of the conventional plasticizers. The spring and dashpot arrangement of Fig. 1 is intended to suggest some of these ideas. The bottom dashpot, which is responsible for viscous flow, is shown with a limiting device corresponding to cross-linking or crystallinity.

Figure 1 portrays the effect of plasticizer addition on modulus of elasticity. Evidently all properties of the base polymer are affected by plasticizer and it is only necessary to consult some of the current papers, such as that of Rider, Sumner, and Myers (*1*), or those of Reed (*2*, *3*), or the book on plasticizers by Buttrey (*4*), to examine the nature of this variation. It frequently happens that the properties so affected are interrelated in a rather intimate fashion. Figure 2 is designed to illustrate the type of interrelation which is believed to exist among three important properties of a plasticized system, namely, compatibility, efficiency, and per-

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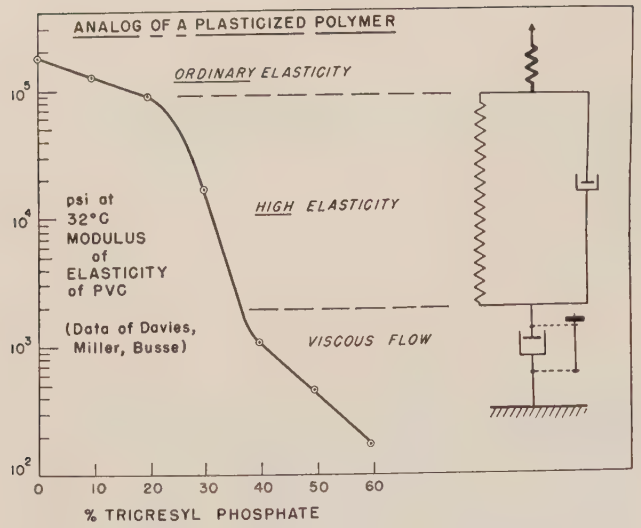

Fig. 1. Modulus of elasticity at 32°C. as a function of plasticizer content, showing a spring and dashpot analog

manence. Compatibility, as the name implies, refers to how much plasticizer can be added to a polymer before phase separation sets in. Efficiency refers to how much good a given amount of plasticizer accomplishes in affecting some specific property, such as brittle point lowering. Permanence refers to how well a given plasticizer remains in the polymer under some specified aging conditions.

Compatibility is affected by the size and shape of the plasticizer molecule and its specific chemical groupings, all related to the base polymer being plasticized. The efficiency seems to depend on the size, the molecular weight, the diffusion rate, and perhaps the compatibility of the plasticizer molecule. Boyer and Spencer (*5*) originally suggested a definite although empirical relationship between plasticizer efficiency and compatibility, although Nielsen, Buchdahl, and Levreault (*6*) have not been able to confirm this finding. Plasticizer permanence appears to depend in part on compatibility and in part on the diffusion rate of the plasticizer (*7*). The rate at which plasticizer is lost from the surface of a polymer by evaporation depends upon the effective vapor pressure of the plasticizer which in turn is a function of the boiling point of the pure plasticizer, and how firmly it is tied into the base polymer, i.e., its compatibility with the polymer. If the rate of loss of plasticizer from the surface layers is high, and such loss is being replenished through diffusion of plasticizer molecules in the interior, then the diffusion constant of the plasticizer in the polymer may play a role in determining rate of loss. Apparently for many ordinary applications, even at elevated temperature, the rate of loss is determined primarily by the effective vapor pressure of the plasticizer. In some cases, such as loss of plasticizer during oil immersion, it might be expected that diffusion rate would assume more significance.

In brief, then, all three of these important properties are related to each other in one way or another. It would almost appear that once a plasticizer molecule has been synthesized so that its shape and structure are fixed, then its behavior on all three of these aspects automatically follows. One of the tasks of the chemist who is designing new plasticizer molecules is to build in special features which will permit, for example, high efficiency with low diffusion rate. Polymeric plasticizers accomplish this purpose.

One property which might be associated with the efficiency in Fig. 2 is the tensile strength of the plasticized polymer since this in turn appears to be related to at least some of the other properties in a rather intimate manner, as we shall discuss later in this report. In fact, in what follows we shall be mainly concerned with the question of plasticizer efficiency and with the relationship of tensile strength to brittle temperature in plasticized polymers (*8*).

EFFICIENCY OF PLASTICIZERS

Figure 3 is a plot of temperature in degrees centigrade against weight per cent of plasticizer for four different types of measurement, any one of which can be used to measure the plasticizer efficiency. The curve on the left shows the decrease in second-order transition temperature with an increasing percentage of plasticizer as determined by Wurstlin (*9*) from the break in the volume temperature plot. The next curve shows some brittle point data (*10*). The third curve from the left represents the temperature at which the modulus of elasticity, as determined by Davies, Miller, and Busse (*11*), had a certain value. The last curve to the right shows how the peak in the thousand-cycle dielectric loss curve drops to lower and lower temperatures with increasing amounts of plasticizer. Aside from the modulus curve, whose location depends upon the exact value of the modulus chosen, the other three curves illustrate a rather typical pattern, namely, that the faster the test the larger the amount of plasticizer needed to lower the characteristic temperature to some definite value. Thus the brittle point temperature is always some 5 to 15° higher than the second-order transition temperature—this difference depending on the actual speed of the brittle point test. The dielectric loss peak will be 20 to 30° higher than the brittle temperature. These plots for the faster tests may be rotated (i.e., a smaller slope) as well as being shifted to higher per cent plasticizer.

Any theory which attempts to explain plasticizer efficiency must answer two questions: one concerns the

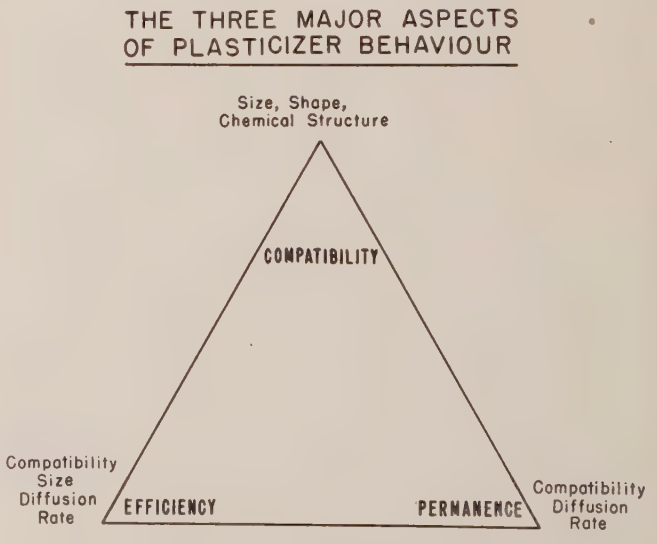

Fig. 2. Schematic representation of relationships between three important properties of the plasticizer, namely, compatibility, efficiency, and permanence

rate at which a given characteristic temperature is lowered by addition of a given plasticizer; the second is how much the characteristic temperature is decreased by constant amounts of different plasticizers. Possibly a third aspect would concern how the speed of the test affects plasticizer efficiency. There have been several different specific approaches to the theory of plasticizer efficiency. Zhurkov (*12*) assumed that each plasticizer molecule shielded the specific polar group along the main polymer chain and since interaction occurred between pairs of groups then a type of second-order equation should apply to the effect of each added plasticizer molecule. On the basis of this assumption he arrived at an approximation valid for small amounts of plasticizer which said that the lowering of the characteristic temperature should be linear with number of molecules of plasticizer added. In other words, it should be linear in the ratio of weight per cent of plasticizer to the molecular weight of the plasticizer. This simple result answered both of the questions set forth above, namely, any given plasticizer should affect a linear lowering of some characteristic softening temperature, whereas different plasticizers should vary, at fixed concentration, in inverse proportion to their molecular weights.

Later on Fox and Flory (*13*) found that the second-order transition temperature of polystyrene fractions varied inversely as the number average molecular weight of fractions. Since addition of a plasticizer or solvent molecule would lower the number average molecular weight in a known fashion, it therefore followed that the transition temperature should decrease linearly with addition of plasticizer, much as predicted by Zhurkov's theory, and as given below by equation (1). In this equation t_o is the transition temperature of the pure

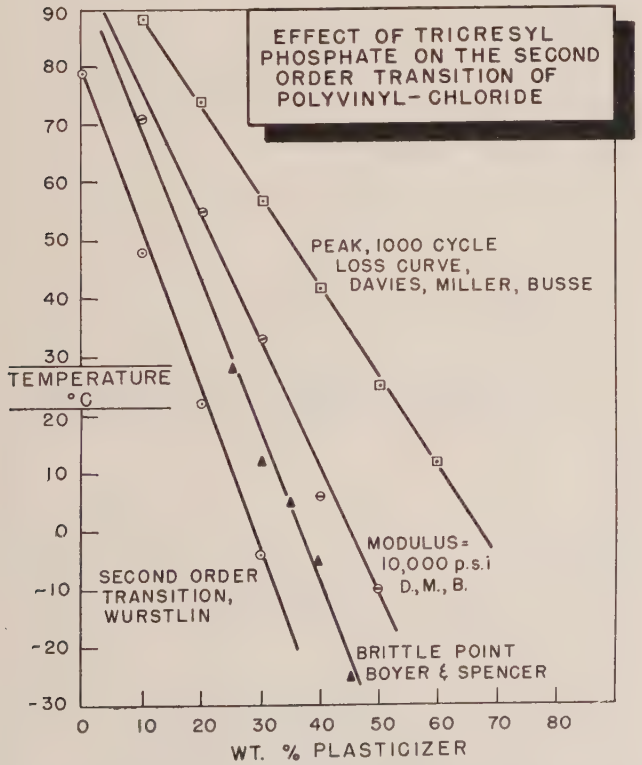

Fig. 3. Temperature vs. composition for polyvinylchloride plasticized with tricresylphosphate, using second-order transition temperature, brittle point, an isomodulus state and the peak in the thousand-cycle loss factor curve as measures of plasticizer efficiency

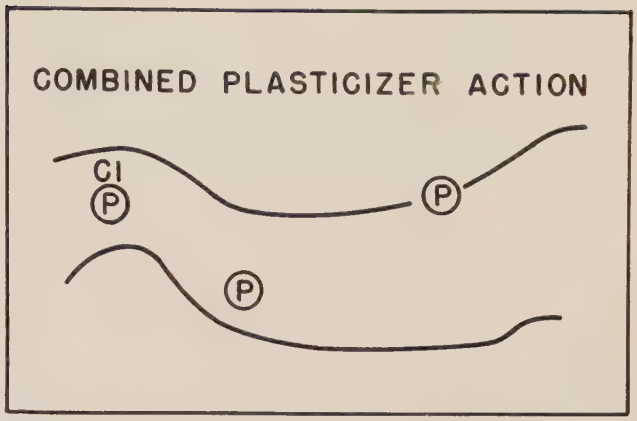

Fig. 4. Schematic representation of different modes of plasticizer action such as shielding of specific polar groups, introduction of end groups, and general lubricating action

Ⓟ represents a plasticizer molecule, Cl is an active group along a polymer chain.

polymer, α is a constant, W_1 is the weight per cent of plasticizer of molecular weight M_1.

$$t_m = t_o - \alpha \frac{W_1}{M_1} \qquad (1)$$

Figure 4 is an attempt to represent some of these things schematically in that the three different plasticizer molecules are shown. One of them is blocking the polar chlorine group in the sense that Zhurkov was discussing. Another molecule is shown between the ends of two polymer chains as it is intended to present an end-group function, or a lowering of the number average molecular weight of the system. In addition, then, a third type of approach would be simply to say that the plasticizer molecule is exerting a spacing action, and separating polymer chains. Boyer and Spencer (*5*, *10*) suggested that the main function of the plasticizer was to lower the melt viscosity of the system. They assumed the transition temperature of the plasticized system to represent an isoviscous state, and arrived at equation (2):

$$\sqrt{w_2} = A - B/T_b \qquad (2)$$

which predicts a linear relationship between the square root of weight fraction of polymer w_2 and the reciprocal absolute transition temperature. Nielsen, Buchdahl, and Levreault (*6*) were also led to a similar equation by assuming the transition point of a plasticized polymer as an isoelastic state. It is also possible to arrive at a similar equation by assuming that the transition point represents an isodiffusion constant state (*8*). In all three cases, then, an equation such as equation (2) results. For our purposes it is desirable to transform this equation slightly and to introduce the molecular weights of the plasticizer and of the polymer into the equation. If the transition temperature in degrees centigrade is not too large in comparison to 273 and if the amount of added plasticizer is not too large, then the reciprocal absolute temperature and the square root of the weight fractional polymer can both be transformed respectively to temperature in degrees centigrade and weight fraction of plasticizer. Then results equation (3):

$$t_m = t_o - \beta w_1(1 - M_1/M_2) \qquad (3)$$

where β is a numerical constant, M_1 is the molecular weight of the plasticizer, and M_2 the molecular weight

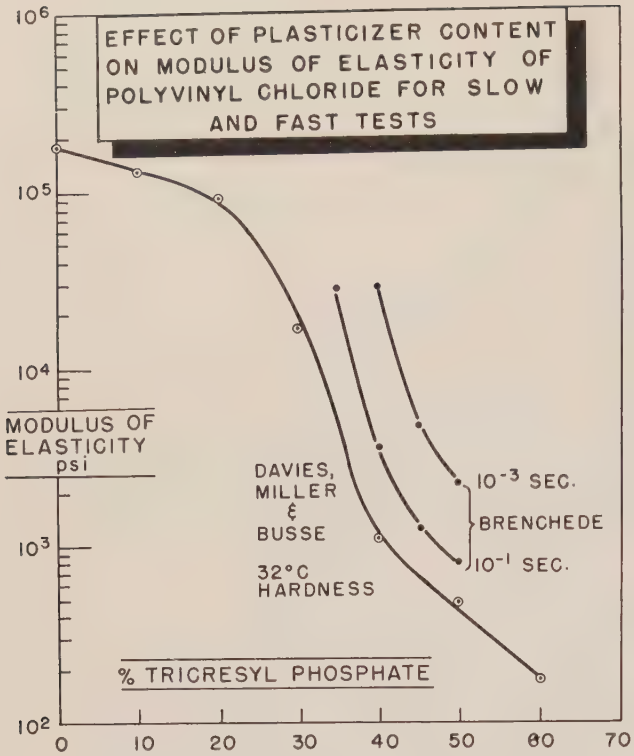
EFFECT OF PLASTICIZER CONTENT ON MODULUS OF ELASTICITY OF POLYVINYL CHLORIDE FOR SLOW AND FAST TESTS
MODULUS OF ELASTICITY psi
DAVIES, MILLER & BUSSE
32°C HARDNESS
10⁻³ SEC.
BRENCHEDE
10⁻¹ SEC.
% TRICRESYL PHOSPHATE

Fig. 5. Effect of speed of test on the modulus composition curve for polyvinyl chloride plasticized with tricresyl-phosphate. The full curve was based on hardness measurements and represents relatively slow test data

of the polymer. For most conventional plasticizers M_1 will be no more than 1% of M_2 and so it would not be anticipated that the molecular weight of the plasticizer would play any pronounced role. Only in the case of polymeric plasticizers where M_1 approaches M_2 does this last factor become important. In fact it would tend to say that high molecular weight plasticizers would be extremely inefficient, which is known not to be the case. Thus equation (3) in effect reduces to the general form of equation (1), namely, a linear lowering of the transition temperature with increasing amounts of plasticizer, but leaving the variation from one plasticizer to another tied up in the constant β in some unspecified manner. The constant β should contain as a factor the reciprocal of the activation energy for melt viscosity. Thus, any plasticizer which caused the activation energy for melt viscosity of the plasticized system to be small would be an efficient plasticizer. A similar type of result occurs in the case of assuming an isodiffusion constant state as given below in equation form, where we have dropped the molecular weight terms and have actually introduced the activation energy for diffusion E_d.

$$t_m = t_o - \frac{\alpha}{E_d} w_1 \qquad (4)$$

Briefly, then, there are the two general types of equations to describe plasticizer efficiency, namely, equations (1) and (4). Equation (1) in essence is the kind where the transition temperature depends on the number average molecular weight of the plasticized system, and where the only specific property of the plasticizer which enters in is the molecular weight. Equation (4) refers to those cases where the weight average molecular weight of the plasticized system is the important variable and where the molecular weight of the plasticizer does not enter explicitly. Instead, the variation from one plasticizer to another comes through some type of activation energy.

The possibility of plasticizer efficiency being clearly related to molecular weight of the plasticizer was definitely shown by Mead, Tichenor, and Fuoss from their dielectric data on polyvinylchloride (*14*). They found that the amount of plasticizer corresponding to maximum loss factor at a given temperature and frequency increased linearly with the molecular weight of the plasticizer. There were two marked exceptions—dibenzyl sebacate and dioctyl phthalate. The dibenzyl sebacate point fell on the general plot if it were assigned half its actual molecular weight, thus suggesting that the two ends of the molecule were acting more or less independently. Mead, Tichenor, and Fuoss conclude that the weight, size, and shape of the plasticizer molecule all have a part in determining its efficiency.

Quite recently Jenckel and Heusch (*15*) have measured the lowering of the second-order transition point of polymethylmethacrylate per mol per cent of various solvents. They found that the relatively long, internally flexible methyl valerate is more than twice as efficient per molecule as the rigid benzene and chloroform molecules.

At the same time Zhurkov and Lerman (*16*) obtained for polymethylmethacrylate data indicating the Zhurkov theory was exactly followed. Their data were more limited in scope than that of Jenckel and Heusch.

Thus, while some of these simple theories which predict a linear dependence of plasticizer efficiency on number of molecules find adequate support in limited sets of data, yet there are numerous marked exceptions. In fact, the very success of polymeric plasticizers whose molecular weights are from a few to manyfold that of conventional plasticizers but serves to emphasize the importance of internal flexibility of the plasticizer molecule. On the other hand, we are not aware of any data which would demonstrate conclusively that plasticizer efficiency follows a molecular weight relation such as that of equation (3).

We have already commented on the fact that plasticizer efficiency decreases with increasing speed of the

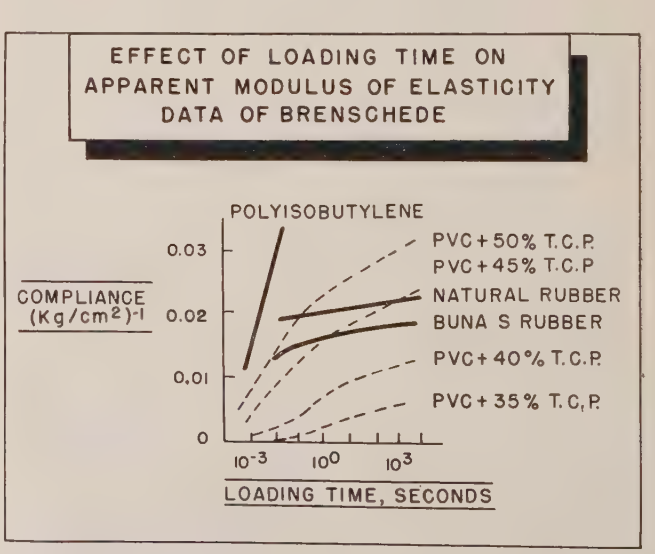

Fig. 6. Composite representation of some data by Brenschede on the compliance of several rubbers and plasticized polyvinylchloride as a function of loading time

test. Figure 5 is a replot of Fig. 1 to which we have added some modulus data obtained by Brenschede (*17*) at relatively fast speeds of testing, namely, at 0.01 and 0.001 of a second. It is evident that increasing amounts of plasticizer must be added to achieve a given modulus as the speed of the test increases. Figure 6 is a composite based on some data by Brenschede in which the compliance as a reciprocal of the modulus is plotted against loading time on a logarithmic scale for several rubberlike materials as well as for polyvinylchloride plasticized with different amounts of tricresylphosphate. An ideal curve is relatively flat, that is, one in which the stiffness does not depend appreciably on rate of loading. Natural rubber is ideal in this respect. We at once are able to gain a picture of the real difference between a rubberlike material and plasticized polyvinylchloride. Whereas plasticized polyvinylchloride can be so compounded that at a fixed rate of loading it has the same compliance as a given rubberlike material, yet its properties are much more sensitive to the frequency than are the true rubberlike materials. In this sense it appears to us that it would be extremely difficult to obtain a plasticized system which duplicates in every respect a good rubberlike material.

RELATIONSHIP OF TENSILE STRENGTH TO THE TRANSITION POINT IN PLASTICIZED POLYMERS

Boyer (*8, 18*) has suggested that the tensile strength, *T.S.*, of a plasticized polymer might be expected to decrease linearly with the weight fraction, w_1, of the plasticizer and inversely as the molecular weight of the plasticizer, as suggested by equation (5) below, where δ is a constant.

$$T.S. = (T.S.)_0 - \frac{\delta w_1}{M_1} \qquad (5)$$

This equation states that the lowering of the tensile strength is in accordance with the decrease in number average molecular weight of the plasticized system. Equation (5) is obeyed approximately by existing data on plasticized polymers such as that of Rider, Sumner, and Myers. Actually, however, it will be found that the depression of the tensile strength is not always in inverse relationship to the molecular weight of the plasticizer, but that other factors apparently enter.

In any event, assuming equation (5) to be correct,

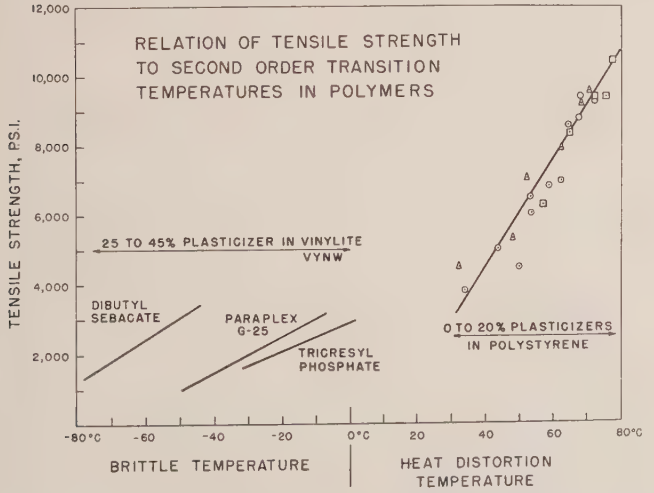

Fig. 7. Tensile strength as a function of transition temperature for polystyrene and for vinylite VYNW. According to equation (5) a straight line independent of type of plasticizer should result

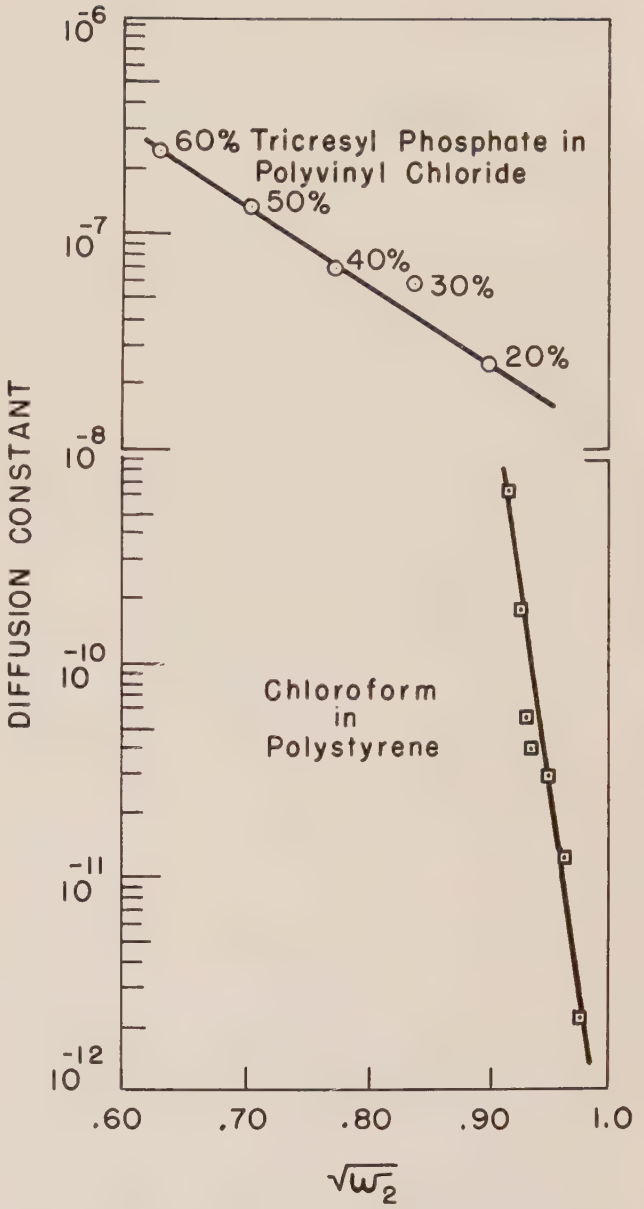

Fig. 8. Diffusion constant plotted against square root of weight fraction of polymer. The figures along the upper curve represent the per cent of tricresylphosphate in polyvinylchloride at 145°C. The bottom curve is for chloroform in polystyrene

then it is apparent that it is of the same form as equation (1), and that the quantity w_1/M_1 can be eliminated between these two equations to give equation (6) below:

$$T.S. = \epsilon + \sigma t_m \qquad (6)$$

which states that the tensile strength should vary linearly with the transition temperature. ϵ and σ are constants. According to this equation ϵ and σ are related to the base polymer and should have nothing to do really with the nature of the plasticizer. In other words, all plasticizers should fall on a common line.

Figure 7 is a plot of tensile strength against temperature for two quite different sets of data. On the right-hand side are some data on polystyrene where the plasticizers have been added in the range of 0 to 20% and the effect on both tensile strength and heat distortion temperature noted. It is seen that to a fair approximation the different plasticizers do tend to cluster around a common line which might be indicated by equation (6). However, when a similar type of plot is made using the

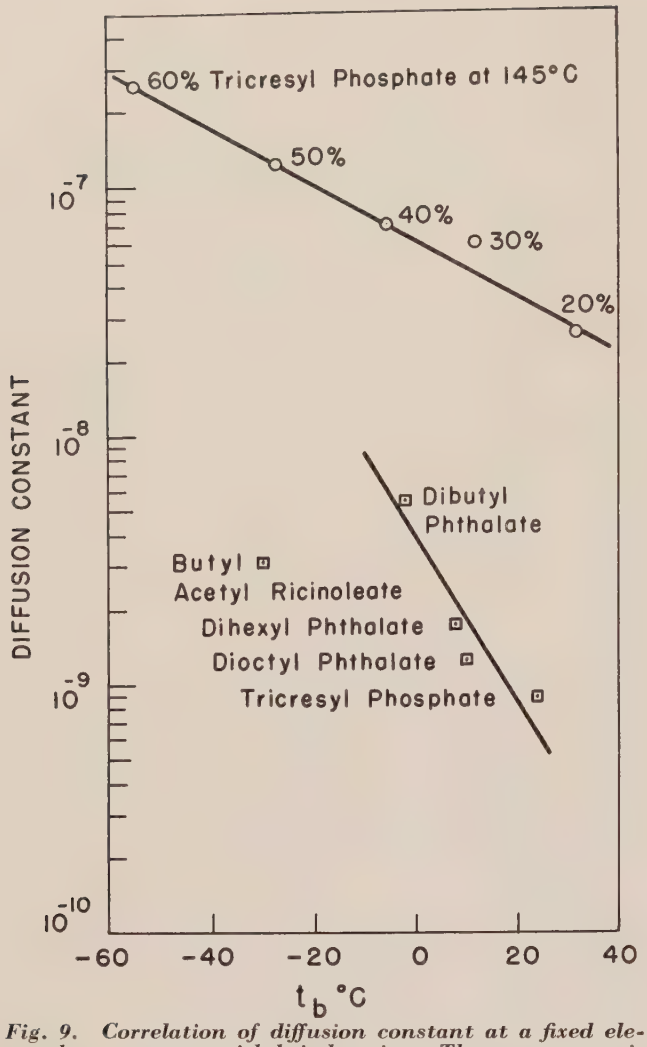

Fig. 9. Correlation of diffusion constant at a fixed elevated temperature with brittle point. The upper curve is for varying amounts of a given plasticizer in polyvinylchloride. The bottom curve is for 33% of different plasticizers in polyvinylchloride at 100°C., using data of Small

data of Rider, Sumner, and Myers on Vinylite VYNW, it is found that while the plots for the individual plasticizers are approximately linear yet each line is quite markedly shifted from that of the other plasticizers. In other words, in this case there is some factor entering in which shifts the brittle temperature quite appreciably without changing the tensile strength values too much as one goes from one plasticizer to another.

We have discussed in more detail elsewhere (*8*) this contrasting behavior between polystyrene and vinylite VYNW. Briefly, we believe that the brittle point data on the vinylite samples involve the ability of the plasticizer molecules to diffuse rapidly at the brittle point temperature, whereas the heat distortion test is so slow as to depend mainly on the number of molecules of plasticizer present. The concept of the brittle point as an isodiffusion constant state has therefore been proposed. As already indicated, this would lead to a behavior such as that suggested by equation (4).

It had already been demonstrated that there was a linear relationship between the square root of weight fraction of polymer and the logarithm of diffusion constant for plasticized polymers (*18*). Figure 8 shows two such plots—in the one case for tricresylphosphate and polyvinyl chloride at 145°C. and in the second case for chloroform in polystyrene at room temperature. The former data are those of Liebhafsky, Marshall, and Verhoek (*19*) while the chloroform data, having a much lower range of compositions, are those of Crank and Park (*20*). From the fact that this square root of w_2 appeared both here and earlier in equation (2) we were led to look for a correlation between the diffusion constant and brittle temperature. Figure 9 is such a plot for two different cases: the upper curve is that of varying amounts of tricresylphosphate in polyvinylchloride which is an excellent correlation. However, the lower curve showing fixed amounts, namely, 33% of different plasticizers, in polyvinylchloride, gave only fair correlation with one point for butyl acetyl ricinoleate, being quite far off the curve. It turns out that these data do follow equation (4) relatively well inasmuch as butyl acetyl ricinoleate has the smallest activation energy for diffusion (*7*) and thus should have the most marked effect in lowering the brittle point at a fixed amount of plasticizer, while tricresyl phosphate has the largest activation energy of the plasticizers shown.

CONCLUSIONS

We have attempted to sketch here some of the typical problems arising in the field of plasticization. We believe it is evident that while certain trends in the behavior of such systems can be predicted with a fair amount of certainty there are many unsolved problems. The exact solution of some of these problems appears to require more fundamental data on such things as melt viscosity of plasticized systems at different temperatures and compositions, diffusion rate studies, also at different temperatures and compositions, as well as the older types of measurements which take into account the size, shape, and molecular weight of the plasticizer. In addition to these various dynamic measurements there is also need for some thermodynamic data relating to the solvation of polymers by different plasticizers.

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Received May 19, 1951. Presented at the Paper-Plastics Conference sponsored by the Technical Association of the Pulp and Paper Industry, Syracuse, N. Y.

Toward a Referee Viscosity Method for Cellulose

A. F. MARTIN

A referee method for cellulose viscosity should combine the following features: reproducibility, rapidity, simplicity, correlation with use properties, correlation with chain length, and applicability to all types of cellulose. The method should also protect the cellulose from degradation during measurement and should encompass the best features of modern techniques of viscometry, including correction for velocity gradient. No existing viscosity method appears to have a suitable combination of all of the features mentioned above. A new possibility for fulfilling the above requirements more completely has been suggested by a statistical study of the errors inherent in using the author's equation relating observed to intrinsic viscosities. It is proposed to use intrinsic viscosity as the reported viscosity value for all samples. Viscosities would be run at a concentration such that for all samples the product of intrinsic viscosity and concentration would always be the same value. Under these conditions, all viscosities would be measured at a standard velocity gradient. Although the expressions given in this paper have been derived on the basis of the Martin equation, the same principles could be applied if other viscosity-concentration relationships were used.

Viscosity is one of the more important test methods for characterizing cellulose and its derivatives. It is related to the strength properties of paper pulp, including tear, tensile, burst, and fold. It helps to determine major operation factors in many processes where cellulose is dissolved in order to transform it into the desired physical form. The viscosity test method, the viscosity of solutions during processing, and the strength of finished products are direct functions of the chain length (D.P.) of the cellulose. In view of the importance of viscosity, it is not surprising that efforts should be continued on improving the test method. All of the major organizations dealing with cellulose, including TAPPI, A.C.S., and ASTM, have subcommittees currently at work on this problem.

Up to the present, efforts to develop a single standard referee method for viscosity have not been successful. There are too many so-called standard methods now in use. The difficulty in reaching general agreement on a referee method for cellulose viscosity appears to lie in the large number of objectives of such a method. It must be a measure of D.P. so it can correlate with use viscosities and with the strength of the finished cellulose products. Adequate reproducibility is essential. The method should be simple, rapid, and within the scope of an industrial laboratory, yet sensitive enough for research use. It should be applicable to all D.P. ranges and to all degrees of purity.

The present referee methods may be correlated to some extent, as in Fig. 1, which shows that in these methods different solvents and viscometers are used, different cellulose concentrations are specified, and different viscosity ranges are encountered. All of these methods, however, have one thing in common: they specify the use of one or more standard concentrations at which the viscosity test is to be run. Industrial practice recognizes that a single concentration is undesirable because it gives so wide a range in finished viscosities that all samples cannot be run in one viscometer. Methods with two or more standard concentrations may partially avoid the wide range of measured viscosities and yet they encounter the complications of having to correlate results at one concentration with those at another concentration.

It is the purpose of this paper to suggest a new technique where viscosities may be measured at a constant value of the product of intrinsic viscosity and concentration instead of being measured at a standard concentration. Using a constant $[\eta]C$ instead of constant concentration will result in several advantages which can be important in a referee viscosity method. It seems desirable to anticipate a description of the development of this technique by listing these advantages:

1. All celluloses will be measured at the same solution viscosity.
2. With this single value of observed viscosity the

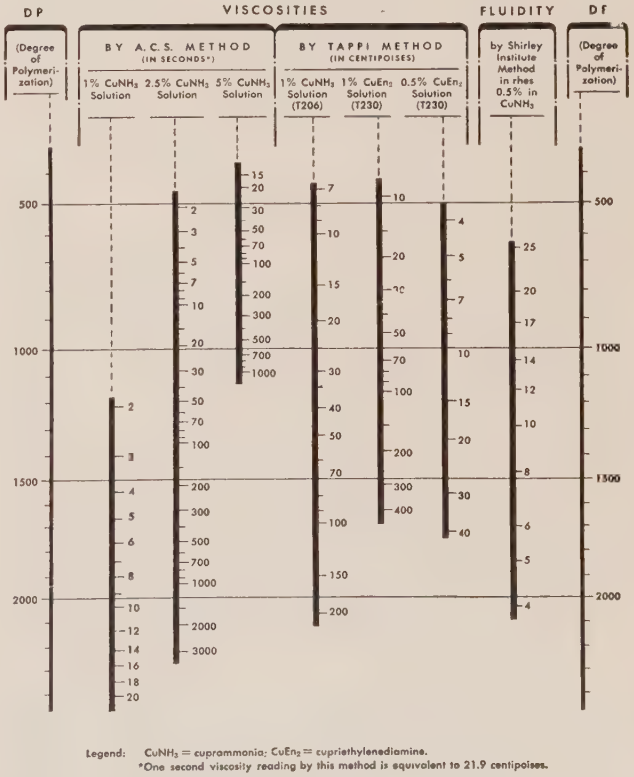

Fig. 1. Hercules conversion chart for cellulose viscosities

(Copyright 1948 by Hercules Powder Co.)

D.P. = 200 $[\eta]$, with $[\eta]$ measured in A.C.S. cupram

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velocity gradient encountered in a given viscometer will be the same for all celluloses.

3. Viscometers may be designed so as to minimize timing and other viscosity errors in addition to giving the fixed velocity gradient.

4. Viscosities would be reported in terms of intrinsic viscosity which may be considered as directly proportional to chain length and, therefore, directly related to the strength properties of the finished cellulose products. (This is now industrial practice with at least one cellulose supplier.)

5. The error in estimating intrinsic viscosity will be the same for all celluloses, regardless of chain length.

6. The use of the standard viscosity will eliminate the occasional need for maximum solvent power with high-viscosity celluloses, and thus will simplify the selection of solvents for the standard test methods.

The use of the product $[\eta]C$ is suggested by a study of the Martin equation which is frequently used to relate observed solution viscosities to intrinsic viscosities. The usual form of this equation is:

$$\log (\eta_{sp.}/C) = \log [\eta] + K[\eta]C \qquad (1a)$$

When this equation is rewritten in the following form, the significance of the product $[\eta]C$ can be seen:

$$\eta_{sp.} = [\eta]Ce^{K'[\eta]C} \qquad (1b)$$

If viscosity measurements are made under conditions such that $[\eta]C$ is a constant, then the Martin equation becomes:

$$\eta_{sp.} = \text{constant} \qquad (2)$$

With specific viscosity constant, observed viscosity is constant also.

The simplified form of the Martin equation which results from making $[\eta]C$ a constant can be plotted, as in Fig. 2. In this plot K' was assumed to have a value of 0.30 which is typical for cellulose dissolved in standard

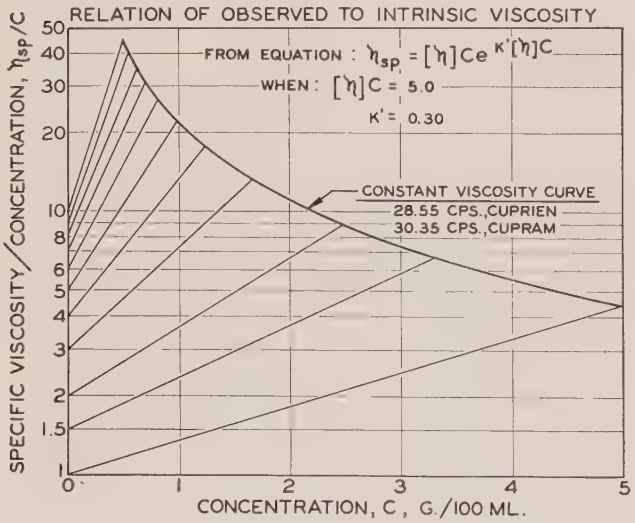
RELATION OF OBSERVED TO INTRINSIC VISCOSITY
FROM EQUATION : $\eta_{sp} = [\eta]Ce^{K'[\eta]C}$
WHEN : $[\eta]C = 5.0$
$K' = 0.30$
CONSTANT VISCOSITY CURVE
28.55 CPS. CUPRIEN
30.35 CPS. CUPRAM
SPECIFIC VISCOSITY/CONCENTRATION, η_{sp}/C
CONCENTRATION, C, G./100 ML.

Fig. 2. Relation of observed to intrinsic viscosity

cupram or cuprien. A value of 5.0 was chosen for the product $[\eta]C$ for reasons to be discussed later. Under these conditions, all celluloses would be measured at a viscosity of 28.55 cp. in cuprien and 30.35 cp. in cupram. This constant viscosity would be obtained, for example, by measuring a cellulose of intrinsic viscosity of 10 at 0.5% concentration and cellulose of intrinsic viscosity of 2 at 2.5% concentration. Mildly treated cotton staple would be measured at concentrations below 0.5% while the usual range of wood pulp and chemical cotton celluloses would be measured at concentrations near the 1% figure now specified in TAPPI

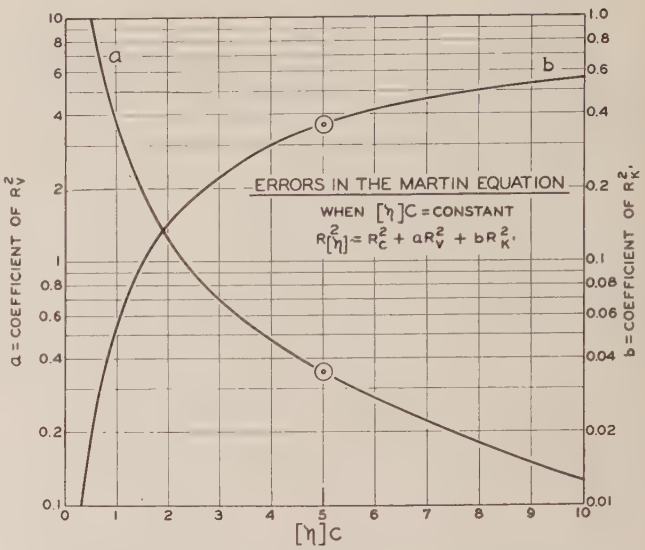

Fig. 3. Errors in the Martin equation

Standards T 206 and T 230. Rayon, hydrocellulose, and similar materials would be measured at even higher concentration. The use of a constant value of $[\eta]C$ means that there is an automatic adjustment of concentration to take care of variations in chain length of the celluloses being tested.

The choice of $[\eta]C = 5$ is based on considerations of the accuracy with which intrinsic viscosity may be estimated from a single observed viscosity measurement. The use of lower values of $[\eta]C$ would mean shifting the constant viscosity curve of Fig. 2 to the left and downward; that is, the observed value of specific viscosity divided by concentration will be nearer to the value of $[\eta]$. With higher values of $[\eta]C$, extrapolation to intrinsic viscosity will be made from a higher concentration.

W. E. Davis of this laboratory will soon publish a study which he has made of the accuracy of estimating intrinsic viscosity from observed viscosity. He has found that the following equation expresses this relationship:

$$R_{[\eta]^2} = R_C{}^2 + \frac{2\left(1 + \frac{1}{\eta_{sp.}}\right)^2 R_v{}^2 + (K'[\eta]C)^2 R_{K'^2}}{1 + K'[\eta]C^2} \qquad (3)$$

The error in estimating intrinsic viscosity is thus a function of the relative error in measuring concentration, in measuring viscosity, and in knowing the slope constant. When the assumption is made that $[\eta]C$ is a constant, this equation reduces to the following form:

$$R_{[\eta]^2} = R_C{}^2 + aR_v{}^2 + bR_{K'^2} \qquad (4)$$

This equation indicates that intrinsic viscosity can be estimated within the same limits for all samples, provided only that the variation in R_C with concentration is small. This is generally the case within practical limits.

A study of equation (4) shows that coefficient a decreases and coefficient b increases with rise in $[\eta]C$ (Fig. 3). This opposing effect means that for any given values of R_C, R_v, and $R_{K'}$, there is an optimum value of $[\eta]C$ which will give the smallest possible error in estimating intrinsic viscosity from an observed viscosity measurement.

Typical curves relating the total error in estimating intrinsic viscosity to the value of $[\eta]C$ are shown in Fig. 4. Concentration and viscosity errors in routine control work should not exceed the values of $\pm 2\%$ and $\pm 3\%$ which were used in the calculations for this figure. The effect of varying $R_{K'}$ between 10 and 25% is indicated. The range of $\pm 25\%$ is the maximum which would be expected according to a study of thirteen different celluloses in various cupram and cuprien solvents. A value of $\pm 15\%$ appears reasonable if specifications for solvent power can be tightened and if a specification for

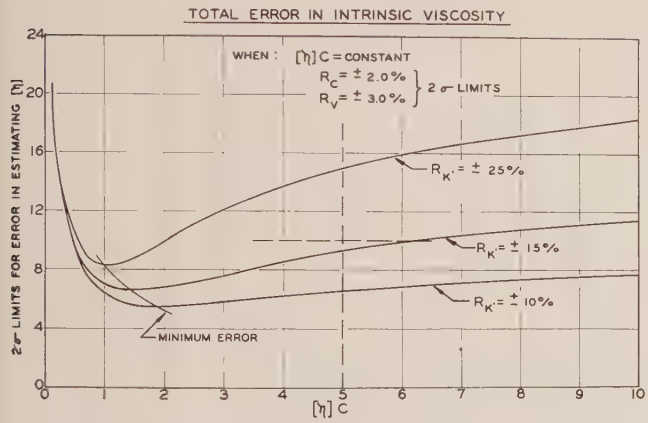
TOTAL ERROR IN INTRINSIC VISCOSITY
WHEN : [η]C = CONSTANT
$R_C = \pm 2.0\%$
$R_V = \pm 3.0\%$
2 σ LIMITS
$R_{K'} = \pm 25\%$
$R_{K'} = \pm 15\%$
$R_{K'} = \pm 10\%$
MINIMUM ERROR
2 σ LIMITS FOR ERROR IN ESTIMATING [η]
[η]C

Fig. 4. Total error in estimating intrinsic viscosity

Example of Use of Nomograph (Figs. 5 and 6)

1. If observed viscosity were 125 cp. (1% concentration in cupram):
   Calculate—$\eta_{rel.} = 125/1.286 = 97.2$
   On Fig. 5, draw line through $\eta_{rel.} = 97.2$ and $C = 1.0$ to intersect bottom line at $[\eta] = 8.0$.
2. From standard value of $[\eta]C = 5.0$, calculate $C = 5.0/8.0 = 0.625\%$.
3. Measure viscosity at 0.625% concentration. If this viscosity were 27.0 cp.:
   Calculate—$\eta_{rel.} = 27.0/1.286 = 21.0$
   On Fig. 6, draw line through $\eta_{rel.} = 21.0$ and $C = 0.625$ to intersect bottom line at $[\eta] = 7.7$.
4. Report cellulose has $[\eta] = 7.7$.

solvent viscosity can be included. It can be seen that when the variations in K' can be reduced to $\pm 15\%$, the total error in estimating intrinsic viscosity from a single observed viscosity determination will not exceed $\pm 10\%$ at values of $[\eta]C$ up to 6. Lower values do not give appreciably better results. An error of $\pm 10\%$ in estimating chain length is entirely satisfactory for most uses. The value of $[\eta]C = 5$ as used above will, therefore, result in reasonable accuracy and yet the concentrations are close to those specified in the present TAPPI viscosity methods.

There still remains the problem of adapting these theoretical considerations for practical use in a referee viscosity method. A referee method must necessarily cover two general types of situations: characterization of an unknown cellulose, and comparison of a known cellulose with standard specifications. The technique of measurement at constant $[\eta]C$ may conveniently be used for both situations. Only one viscosity measurement is necessary to determine if a known cellulose fits the specifications. Two measurements are generally necessary to characterize an unknown sample. The following examples will illustrate the techniques which may be employed.

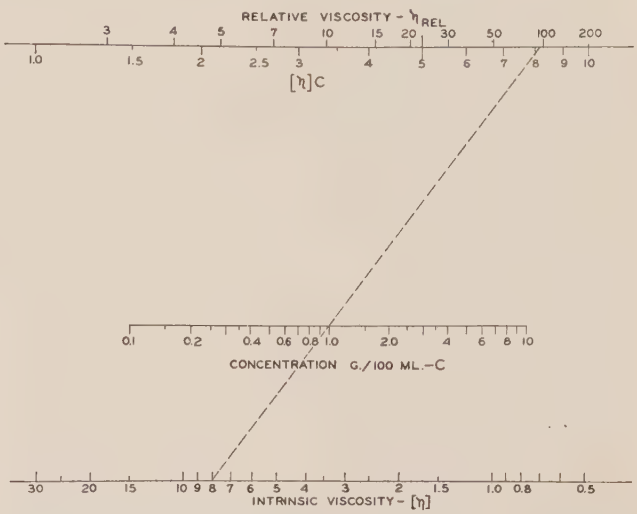

Fig. 5. Nomograph relating observed and intrinsic viscosities. Cellulose in cupram or cuprien solution

Martin equation: $\eta_{rel.} = 1 + [\eta]Ce^{0.30[\eta]C}$

The procedure for an unknown cellulose would be as follows:

Prepare a solution of the cellulose in a standard solvent at any convenient concentration, using the value of 1% if the knowledge of the sample does not suggest a different value. Measure the viscosity of this solution

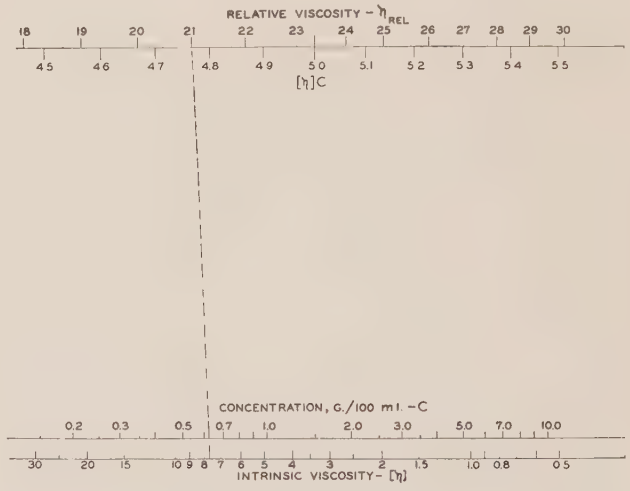

Fig. 6. Nomograph relating observed and intrinsic viscosities. Cellulose in cupram or cuprien solution

Martin equation: $\eta_{rel.} = 1 + [\eta]Ce^{0.30[\eta]C}$

in the standard viscometer. Use a nomograph such as that given in Fig. 5 to determine an approximate intrinsic viscosity. From this value, and the standard value of $[\eta]C = 5$, calculate the value of C which should be used in the standard viscosity measurement. Make up a new solution at this concentration and measure the

viscosity again. Calculate the revised intrinsic viscosity from a second nomograph (Fig. 6). This procedure should be repeated if necessary until the observed viscosity measurement lies within ±20% of the standard value (28.55 cp. in cuprien and 30.35 cp. in cupram). The reported viscosity value for the cellulose should be the intrinsic viscosity obtained from the nomograph using the viscosity measurement which is within 20% of the standard.

The manner in which specifications might be written can be shown, using as an example wood pulp for smokeless powder which is now covered by Joint Army-Navy Specification JAN-C-216. The present specifications are 50 to 100 seconds A.C.S. 2.5-gram concentration. These viscosities correspond to a D.P. range of 1190 to 1350 and to an intrinsic viscosity in cupram which averages 6.35 (see Fig. 1). This intrinsic viscosity of 6.35 would be used as the proposed specification average. Such a cellulose then made up in 0.788% solution will give the standard observed viscosity of 30.35 cp. in cupram. The specification limits may be set by an allowable range in the observed viscosity at the specified 0.788% concentration. It can be calculated that in order for the specification limits to be the same as the present 50 to 100 seconds, the observed viscosity in the new method should be held within the range of 26.1 to 35.3 cp.

To summarize, this paper suggests a technique for measuring viscosities of celluloses under conditions such that a constant viscosity is obtained and the velocity gradient is held at a selected value. An automatic compensation for chain length of cellulose is made by changing the concentration of the solution. The method appears suitable for both routine and research use. No attempt has been made to choose a solvent which might be best for use with this method. It is, however, extremely important to choose a solvent with uniform solvent viscosity and with uniform solvent power at the $[\eta]C$ value chosen. This paper is presented with the hope of pointing to a method of measuring disperse cellulose viscosity which has both practical and theoretical advantages.

NOMENCLATURE

D. P.	= degree of polymerization (average number of anhydroglucose units per cellulose molecule)
cupram	= cuprammonium hydroxide solution
cuprien	= cupriethylenediamine solution
η	= observed solution viscosity
ηo	= solvent viscosity
$\eta_{rel.}$	= $\eta/\eta o$ = relative viscosity
$\eta_{sp.}$	= $\eta_{rel.} - 1 = (\eta - \eta o)/\eta o$ = specific viscosity
C	= concentration, grams per 100 ml. of solution
K'	= 2.303 K = slope constant in Martin equation
$R_{[\eta]}$, R_C, R_v, $R_{K'}$	= relative error in $[\eta]$, C, viscosity measurement, and K', respectively
$[\eta]$	= $\lim (\eta_{sp.}/C)_{C \to o}$ = intrinsic viscosity

RECEIVED Feb. 15, 1951. Presented at the Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb 19–22, 1951.

Peter Van Wyck and W. E. Davis contributed valuable assistance in the preparation of this report.

Operation of Sludge Recovery Kilns

R. S. WALKER

The construction and operation of rotary kilns for processing sludge from a causticizing system are given.

RECOVERY of lime sludge from causticizing plants in the paper industry was started about 30 years ago. In the early days, with cheap labor and fuel, any type of reburning showed a tremendous saving over purchase of commercial lime. In addition, some mills were forced into reburning of sludge by the problem of the disposal of the waste carbonate produced by using commercial lime.

The early kilns in the paper industry were small in diameter and about 100 feet long. In the cement industry during the development of burning cement clinker, the original kilns were about 6 by 100 feet, and the early paper mill installations were, no doubt, patterned after the cement industry.

In recent years the paper industry, as in the cement industry, has spent more time and effort on the economies of rotary kiln operation reducing the cost and improving the quality of the product produced. Also, in recent years, make-up lime has been provided in the form of calcium carbonate or limestone being fed to the kilns with the reclaimed recarbonated sludge.

Early in the 1930's the author participated in a great number of tests in the development of an electric furnace for the production of lime and pure CO_2 gas. Some of these tests were made in the General Electric Co.'s laboratories at Schenectady.

In order to arrive at the various factors affecting porosity, surface area of lime particles, and slaking properties, a number of tests were made to develop information involving these features. It is very definitely established that if calcium carbonate is heated too rapidly in the intermediate or preheating zone of a kiln, the physical properties of the resultant lime will be seriously affected. For best paper mill operation, recarbonated lime sludge should have a preheating time of approximately 1 hour. This is assuming material below $^1/_8$ inch in size. Following the preheating zone, for best activity and best settling rate, the material should be calcined at temperatures not exceeding 2100°F., which would mean, a flame temperature in the kiln of approximately 2400°F.

Based upon the information developed and outlined above, the author purchased and installed in 1936 the first 400-foot kiln in the commercial lime industry. Also, in 1940 the author recommended and sold what is believed to be the first 300-foot kiln in the paper industry. Both of these installations not only showed fuel economy but bore out in commercial production the physical characteristics of low-temperature preheating and calcination which had been developed experimentally.

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Impurities in the sludge, especially soda in the various forms, have a tendency to act as a binding agent and form rings in a kiln. A number of tests were run at the plant of the Vermont Marble Co. in an attempt to nodulize New England granular limestone which has approximately the same physical characteristics as recarbonated sludge, except that it is free from all impurities and very low in silica. Soda was added in the form of commercial water glass to the kiln feed. The amount of soda was found to be very critical for best nodulization. Too much water glass would eliminate nodules entirely as would too little. After several weeks of experimenting in an 8 by 130-foot kiln, the soda was accurately weighed and calibrated with the feed and added to the limestone at the rate of 0.7 of 1% as Na_2O. With 0.7 of 1% of Na_2O, practically all of the lime was discharged from the kiln in firm pebbles. The foregoing cited experiments, which process is covered by patents, indicate how critical it is to have the proper percentage of soda, expressed as Na_2O, in the kiln feed, to obtain the best results. The fuel used in the kiln was bunker C oil.

Kilns in the paper industry today vary in diameter from 7 to 11 feet and in length from 100 to 350 feet. In other words, the length is 20 to 50 times the diameter.

Any kiln installation in the paper industry should be made only after a careful study as to operating costs of various sized units versus capital investment required for the larger and longer kilns and should be balanced with fuel costs and quality of product produced. Where fuel is expensive, unquestionably, longer kilns should be given very serious consideration.

Any sludge recovery kiln may be considered to have three zones. The first zone for eliminating the moisture, the second zone for preheating zone, and the final zone for calcining.

In the more recent kiln installations, the first or drying zone is equipped with chains for heat exchange. The sludge is taken in thin layers or coatings on the chain into the gas stream which gives more surface area exposure to the hot gas and aids in moisture evaporation giving maximum efficiency from the waste gases.

A number of designs for installing chains are available. The type and manner of chain installation are not as important as the engineering of the proper amount and spacing of chain for evaporation of the moisture to be fed to the kiln. Tests indicate that for the best nodulizing results, the sludge should leave the chain section containing 20 to 22% moisture, and the chain section should be designed from the heat balance of the kiln to produce this result. A sample hole should be installed at the discharge end of the chain section, and the material out of the chain section should be checked for moisture content at periodic intervals.

The intermediate or preheating zone is the zone in which as much heat as possible should be conserved and passed into the chain section, or first zone, for the evaporation of moisture. Since the heat contained in the gases of combustion and the liberated CO_2 gas from the calcining zone are never sufficient to evaporate the moisture contained in filter cake, any heat lost in the intermediate zone of the kiln must be replaced with fuel. For this reason the intermediate zone of many kilns is now insulated. Refractory life is increased by the insulation with conservation of heat in the hot zone.

Since the manufacture of lime from either limestone or recarbonated sludge is dependent on time and temperature, in short kilns the lime is calcined at a high temperature in a shorter period of time, and in long kilns, the calcining zone is lengthened and the temperature reduced. The longer calcining zone produces a softer burned lime because of the lower temperature and a calcium oxide which is more readily and quickly available to the causticizing reaction.

The calcining zone is in proportion to the total length of the kiln. In so-called short kilns, this zone is often as short as 25 or 30 feet, while in long kilns it can be extended to as much as 90 or 100 feet. Extension of the hot zone and the flame and corresponding increase of the time element permit reduction of the flame temperature. For example, to calcine a 1-inch sphere of limestone at 2200°F. requires about 25 minutes, while to calcine the same stone at 2000°F. requires about 35 minutes, and at 1900°F. requires about 50 minutes.

The foregoing record of tests of time elements is typical of differences in the lengths of time and temperature which can be applied to a hot zone.

The physical characteristics of the flame are also most important. The flame should be confined as nearly as possible to the center line of the kiln without impinging on the kiln lining. To obtain a flame of this kind, the velocity of the fuel and the percentage and velocity of the primary air are controlling factors.

It is impossible to observe properly the physical characteristics of a flame by looking through the kiln hood. The flame in the kiln may appear to be perfect. At the same time the flame may have the shape of a tulip and perhaps 50% of the fuel burned within a short zone 30 or 40 feet back in the kiln. Firing conditions have been experienced in rotary kilns which will produce a temperature 30 to 40 feet from the discharge end for a distance of 6 to 8 feet, 300° or 400° higher than the remainder of the hot zone. A condition of this kind has a tendency to overheat that portion of the hot zone, flux lime with the lining, and, with the soda present, to form rings. All of this can happen while to normal observation the kiln appears to be operating perfectly and the flame appears to have a normal heat distribution throughout the calcining zone.

If a particularly high-temperature short zone occurs in the calcining area, the tendency is to volatilize certain soda compounds which will condense in the cold end of the kiln and set up a circulating and increasing proportion of soda being delivered to the calcining zone. A condition of this kind will have a tendency to form hot zone soda rings. The only way actually to prove the heat distribution over the hot zone is to shut off the flame and then take shell temperatures at various points in the hot zone with an optical pyrometer focused on the kiln lining. If a condition of this kind exists, burner and primary air should be changed to give flame characteristics.

PROBLEMS OF SLUDGE KILN OPERATION

Assuming that sludge from a causticizing system is properly washed, impurities removed, and that the soda expressed as Na_2O is reduced to 1% or less, many of the common operating difficulties and their elimi-

nation and control can be covered by four headings: (1) control of the kiln feed, (2) control of the kiln speed, (3) control of the flame and calcining zone, and (4) control of draft and temperature.

Many kilns are operating today by taking recarbonated sludge at the rate at which it is discharged from the mud washer and pumping it direct to a filter. Irregularities of flow occur in the various steps of the causticizing operation, especially in the white liquor clarifier and in the mud washer. These irregularities are further increased by the variation in the settling properties of the recarbonated sludge with the result that the flow of solids will vary as much as 2:1 ratio when taken direct from the mud washer.

Another variable is brought about by the irregularity in the filterability of solids of any causticizing operation causing the filter cake thickness to vary even with a constant level in the filter box.

Another variation occurs intermittently in the amount of moisture retained in the filter cake for delivery to a kiln. This also is accentuated by the variation in the filterability of the mud to give an irregular percentage of moisture in the kiln feed.

Probably, the most influential factor in so-called mud or cold rings in the feed end of a rotary kiln is a variation in the amount of feed and percentage of moisture in the feed. For example, since more heat or actual B.t.u.'s are required to evaporate the moisture from filter cake than is required for the heat of dissociation, a small variation in moisture in the feed will very rapidly either cool or overheat the feed end of the kiln. When the feed end gets too cold due to increased moisture in the kiln wet material is carried further down the kiln toward the discharge end and tends to adhere to the kiln shell, and when the ratio of heat is returned to normal, bakes on the kiln shell forming mud rings.

This condition has been overcome to a large extent in more recent installations by installing a storage tank for the washed mud delivered from the mud washer. A storage tank of this kind should have minimum 18-hour capacity, and the mud should be diluted in the storage tank to a uniform consistency of approximately 35% solids. In addition to helping to provide a constant feed to the kiln, the tank will provide storage to take care of enforced shutdowns on either side of the storage tank. A small mechanical agitator requiring little horsepower serves to keep the solids in suspension. Rather than depend upon the filterability of the mud to determine the feed to the kiln, a slurry Ferris wheel feeder is used to feed the slurry to the filter or centrifuge so that during every minute of kiln operation the same weight of solids is delivered to the kiln and approximately the same amount of moisture. If a standard filter is used, the overflow on the filter box is closed and the slurry under the filter permitted to find its own level with a constant feed regardless of the filterability of the mud. When a centrifuge is used to feed the kiln and remove the moisture from the slurry, the same slurry feeder is used to feed the centrifuge. Probably the most important factor in the satisfactory operation of a sludge recovery rotary kiln, whether long or short, is regularity of feed, not only in amount of solids but in percentage of moisture to the kiln.

When limestone is used as make-up it has been found more desirable to purchase it from $^1/_4$ to not exceeding $^3/_4$-inch sizes and to feed the limestone into the sludge conveyor near the discharge point so that the limestone actually mixes with the sludge.

KILN SPEED

The kiln speed is probably the second most important item in a sludge reburning operation. Many kilns are equipped with either two-speed, four-speed, or slip ring motors in order to vary the speed of the kiln. The speed of the kiln controls the time of retention of the material. Also, it controls the depth of the load in the kiln for a fixed feed and the time of exposure to the heat.

It is quite common practice for a kiln operator to change the speed of the kiln because the kiln was getting cold in the calcining zone. For example, if the kiln motor is a four-speed motor; 1200/900/600/450, and the normal operating speed is at 900 r.p.m. of the motor, a kiln operator will drop to the 600 speed which runs the kiln two thirds as fast. The kiln operator will make this change without notifying the filter operator and, obviously, since the same rate of feed continued to go to the kiln, the load in the kiln at the feed end during the period of operation at the lower speed would be 50% heavier. The operator reduces the speed in order to get the temperature up in the hot zone. After normal conditions have been achieved by the slower speed, the operator puts the kiln back in the 900 speed, again without notifying the filter operator. Sometime later the heavier load which has been put in the kiln earlier reaches the hot zone and the kiln will again get cold, with the result that the operator again will go to the lower speed and put another heavy load in the feed end of the kiln. It is, therefore, only a question of time until the kiln operates continuously in the second speed with a heavy load which is harder to calcine since the only heat transfer in a rotary kiln is to the surface of the load.

All of the foregoing outlined irregularities help in the formation of rings and could be eliminated by synchronizing the kiln feed with the kiln speed.

Probably more important is the fact that since the major heat transfer available is on the surface of the load by direct radiation, a very definite speed, with each size kiln and with each individual type of sludge, will be the best operating rate. Often rotary kilns are operated at such a slow speed that the load will carry up the side of the kiln and then slide down in a body. The speed of the kiln should gradually be increased until the load continuously tumbles and rolls so that it turns over and the material that is in the center and on the bottom of the load comes to the top. There is no formula to predetermine the correct speed of a rotary kiln since individual kiln linings and sludges have different properties in different plants. This is the reason the author recommends a V-rope drive between the kiln drive motor and speed reducer so that the sheaves can be changed, if necessary, to obtain the proper normal operating speed, to be further controlled in operation with a multispeed or variable speed motor. Once the correct speed for a kiln has been determined and the feed to the kiln made regular at all times, there is no reason to vary the speed of the kiln since minor changes in temperature can be taken care of by changes in the flame and with the fuel. Modern rotary

kilns are gradually approaching a uniformity of kiln speed with feed and fuel as the variables.

HOT ZONE AND FLAME CONTROL

The question of instrumentation is always a problem in the discussion of rotary kiln operation. Hot zone temperatures and delivery of heat from the calcining zone to the intermediate zone and to the feed end of the kiln (or zone of moisture evaporation) are of course involved.

The draft control is probably the most important item in the instrumentation. The induced fan functions on volume. The volume is affected by irregularities in the liberation of the CO_2 gas, irregularities in the amount of moisture in the feed and its liberation, and most important, irregularities in the temperature and corresponding volume in the gases actually delivered to the fan. The draft should be maintained at a constant minus pressure at the discharge end of the kiln, or in other words, in the kiln hood. Most kilns are now equipped with an automatic draft control functioning from the minus pressure in the kiln hood. A close observation of the draft controller over a period of 2 or 3 hours, even with a kiln having a uniform feed and apparent constant operating condition, will indicate that the draft controller works continuously. No kiln should be operated for the recovery of sludge without an automatic draft controller.

Another important factor of instrumentation is flame control and stabilization of temperatures. Most recent installations of sludge recovery kilns provide for a thermocouple at the feed end of the kiln to record the temperature of the gases leaving the kiln. A decrease in temperature at the feed end of the kiln will indicate very quickly if the wet material is traveling down the kiln too far, or an increase will indicate a lack of feed to the kiln. In addition, the temperature should be indicated by a thermocouple with collector rings at the outlet of the chain section. The temperature at the outlet of the chain section is more important than the temperature at the feed end of the kiln for control of the moisture to be evaporated, and will indicate moisture changes more quickly.

The hot zone temperature of a rotary kiln has always been a problem. Some kilns are equipped with optical or radiation pyrometers which focus on the kiln lining through the kiln hood. The optical pyrometer or electric eye registers a shade of blue on a white material of varying shades of white and is therefore inaccurate. It is impractical during operation to focus either a radiation or an optical pyrometer at distances of over 10 or 12 feet from the discharge end of the kiln. When an instrument of this type, if focused at the discharge end of the kiln, registers a drop in temperature, it means that the kiln has become cold in the intermediate zone and that the drop in temperature has been in progress for probably an hour before it is indicated. Therefore, it will require a considerable length of time to get the kiln back to normal operation. As an alternate to either one of the above, the installation of a thermocouple at the entrance of the calcining zone, or where the temperature in the kiln should be approximately 1600°F. is recommended. A change in temperature at this point will indicate to the operator that the kiln is starting to get cold or hot and, if promptly handled, can be corrected before a quantity of underburned or overburned lime is produced because of a low or high temperature.

Some kilns are equipped with continuous CO_2, CO or O_2 analyzers. Because of the dust entrained in the exit gases leaving the kiln, instruments of this type are difficult to keep in operation because of the filters required for the sampling line. Probably a more accurate method of obtaining the proper heat balance is to check the kiln gases with an orset and then determine the proper conditions under which the kiln should operate. Control can then be obtained from temperatures with occasional gas analysis checks. The author strongly recommends the use of a continuous CO_2 and O_2 analyzer but only if they are maintained, supervised, and kept in accurate operation.

FUELS

The conventional fuels for reburning sludge are bunker C fuel oil or natural gas. Pulverized coal is not used because of ash contamination. Gas producers using bituminous coal are hard to control and cause an irregular operation because of lack of fuel control to the kiln.

Oil is introduced into the kiln by means of steam or mechanical atomization. In the author's opinion the best flame under present-day operations seems to be mechanical atomization at pressures ranging from 400 to 800 pounds. A number of types of gas burners for natural gas are available and a gas burner should be adopted which will give a long lazy flame and not a short bushy flame such as the ones used in boilers.

With either type of fuel it is advisable to use a primary air fan and supply the primary air required for combustion directly around the fuel burner or with the fuel. The primary air required for bunker C oil usually runs 30 to 35% and with natural gas runs 60 to 80%. The burner pipe and tip should be designed so that the velocity of the primary air and fuel at the burner tip will give a flame of the proper physical characteristics.

GAS SCRUBBING EQUIPMENT

Many types of wet gas scrubbing equipment are in use by the paper industry and many types are offered to the paper industry by various manufacturers.

Some gas scrubbing equipment, while efficient, requires considerable horsepower and maintenance and is expensive not only to operate but to keep in operation. Recently, several very simple methods of scrubbing kiln gases have been developed requiring very little horsepower.

In the more modern sludge kiln operations, the cold end temperature of the kiln gases will run from 250 to 400°F. The heat in these gases can be used in the scrubber to heat the water which is used for dust collection by recirculation. The water used for dust collection can be built up to a consistency of 10% solids by recirculation. A quantity of it can be bled off and replaced with fresh water to keep the percentage of solids at or below 10%. The hot water containing dust can be used in the mud washer or held in a settling tank and returned to the filter or centrifuge for kiln feeding. By either method the dust that is reclaimed can be returned to the system.

Received Nov. 1, 1950. Presented at the Alkaline Pulping Conference sponsored by the Technical Association of the Pulped Paper Industry, Jacksonville, Fla., Oct. 25–27, 1950.

Case Studies in the Application of Industrial Statistics to Papermaking

CHARLES A. BICKING and RICHARD T. TRELFA

Five case studies of actual applications of industrial statistics to papermaking which describe control activities at a very practical level are included. The first explains how control charts were used to reduce variation in basic weight across the paper web as well as in the machine direction of the paper sheet. The second covers the use of frequency distributions to analyze and portray changes in basis weight and headbox freeness. The third case study describes the use of significance tests to measure and improve the precision and accuracy of two analysts using greaseproof test data. The fourth uses control charts to demonstrate how the number of errors made by paper sorters was drastically reduced. The final case study employs the analysis of variance technique to investigate paper testing technique with the purpose of improving critical factors in the water penetration test. Four testers and eight different papers were involved. Each study includes presentation of all the original data, description of the method of statistical analysis, and careful summarization of the interpretation, action taken and results. A list of references is included as well as a statistical appendix which shows all the computations involved in each study.

THE pulp and paper industry has made great strides in the process control of quality by statistical methods since Catlin's (*1*) pioneering article on the subject in 1944. The increasing number of publications in paper industry and statistical journals is one indication of the rate of this growth. It is significant, also, that many experts in the manufacture of pulp and paper have taken active parts in the work of technical societies interested in fostering statistical quality control. Furthermore, a number of the top men in the quality control profession have achieved places of responsibility in paper mills and have brought to the industry the benefits of their experiences.

One thing indicated by this trend is that management has become aware of the potential savings by this new approach to improvement in uniformity and reduction in waste. A great number of companies have gone beyond the exploratory stage and have in motion or are ready to set up a full-scale modern quality control program.

In order to begin applying statistics to the study of methods of testing or to process control, many technical people from the industry have obtained some training in the basic techniques. As in many such situations, a little knowledge may lead one to pitfalls. To help those who are eager to master the techniques, much greater attention to quality control in the meetings and publications of the trade associations is warranted. This paper presents several case studies of actual applications which may help those who are engaged in control activities at a very practical level.

These case studies cover a variety of problems met with commonly in mill control. Beginning with the very simplest approach to the analysis of data, they develop gradually in the rigorousness of statistics required. The examples given by no means cover all the types of problems which are effectively handled by statistical methods. They may be considered as starting points from which even more effective studies may be made.

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CASE STUDY I

Problem: Control of a paper machine to reduce variation in measurements across the machine as well as in the machine direction.

Data: Basis weight in pounds per 1000 square feet was obtained on each of five samples 12 inches square taken from front, front middle, middle, back middle, and back positions across a 90-inch reel. These measurements for 40 consecutive reels made before the installation of quality control are shown in Table I.

An exactly similar series of measurements made 6 months after the quality control system was begun is given in Table II.

Customer specifications on this paperboard were: 50 pounds per 1000 square feet plus 5%.

Analysis: The first stage in analysis of these data is indicated in the tables. Reel averages and reel ranges, or the difference between the highest and lowest measurements in each reel, were calculated. Also, a column is given in the tables showing moving ranges of averages. This step merely involves taking the difference between successive pairs of reel averages. Reel ranges and moving range of averages were computed only for the first 25 reels in each table because that constituted enough data for the next stage in the analysis. Grand averages and average ranges are obtained for the 25 reels as shown at the bottom of the tables.

It may be interjected here that casual examination of the data in these two tables may lead to some very definite conclusions regarding the pattern of variation across the machine and in the machine direction. However, such a visual analysis of the data is limited to characterizing the *usual* pattern of variation. It becomes too cumbersome a method for use in comparing the changes in pattern of variation from time to time or even for picking out the *unusual* features of variation in a single run of paper. Even the most up-to-date electronic instruments which record a profile of measurements in either direction on the web of paper do not separate, without some kind of statistical analysis,

the unusual from the usual pattern of variation. The idea that unusual variations must be detected and their causes removed is basic to the use of control charts in process control.

The reel ranges and moving ranges of averages given in the tables are essential for the computation of control chart limits. Reel ranges are useful in determining limits of usual cross-machine variation. Moving ranges of averages are used as a means of setting limits for usual variations in the machine direction. It requires little consideration to arrive at the conclusion that the kinds of things which affect variation in the two directions are quite different and often unrelated. It is apparent, for example, that adjustment of the sluice, though it would change the pattern across the machine and might change the size of a measurement at a given position on the reel, would have comparatively little effect on variability at that position throughout the rest of the reel. Similarly, causes such as fluctuating level in the headbox of the paper machine, changes in machine speed, or in consistency of the stock all contribute to a pattern identifiable only in the machine direction of the paper sheet.

Reel range, being a direction measure of cross-machine variability, is in no way dependent upon the average level of basis weight measurement but is dependent only on the uniformity of basis weight across the sheet. There are several ways in which these reel range values may be used to secure reduction in the size of cross-machine variation as well as to make it more consistent. One alternative to the method followed in this paper is to treat the reel ranges in the same manner as single measurements of any variable property of the sheet.

Control chart limits are computed by use of formulas and constant factors which have been published widely, for example, in a manual of the American Society for Testing Materials (*2*). For the period before the start of the quality control system, limits for a control chart for cross-machine variation were found to be 10.1 pounds per thousand square feet for the upper limit and zero for the lower limit. The computations involved in this and the other statistical analyses described in this paper will be found in the Appendix at the end of the paper.

The upper left portion of Fig. 1 shows the reel ranges plotted within the above limits. One reel, No. 4, is out of control. Upon examining the data, it appears that the front reading of reel No. 4 may be in error. If the range for reel No. 4 is eliminated and limits are recomputed (0 and 9.6) all ranges are found to be in control.

Limits for control for machine direction variation are calculated, using the appropriate formula from reference (*2*), as 52.94 and 47.98 pounds per 1000 square feet.

The lower left portion of chart No. 1 shows the reel

Table I. Basis Weight of Paperboard Before Start of Quality Control System

Pounds per 1000 Square Feet

Reel no.	*Front*	*Front middle*	*Middle*	*Back middle*	*Back*	*Reel average*	*Reel range*	*Moving range of averages*
1	56	49	56	52	55	53.6	7	
2	53	49	53	49	54	51.6	5	2.0
3	51	49	52	51	55	51.6	6	0
4	61	50	51	55	55	54.4	11	2.8
5	55	50	51	48	52	51.2	7	3.2
6	48	52	51	49	54	50.8	6	0.4
7	53	50	48	49	53	50.6	5	0.2
8	53	51	53	50	51	51.8	3	1.2
9	54	54	49	52	52	52.2	5	0.4
10	52	51	49	49	52	50.6	3	1.6
11	48	52	49	48	51	49.6	4	1.0
12	50	48	49	50	48	49.0	2	0.6
13	48	48	48	48	49	48.2	1	0.8
14	51	48	50	47	50	49.2	4	1.0
15	46	47	51	45	49	47.6	6	1.6
16	53	51	49	47	48	49.6	6	2.0
17	52	49	48	51	49	49.8	4	0.2
18	52	51	50	49	51	50.6	3	0.8
19	53	49	50	47	51	50.0	6	0.6
20	52	51	48	47	51	49.8	5	0.2
21	53	48	50	50	50	50.2	5	0.4
22	50	50	49	48	53	50.0	5	0.2
23	48	52	50	49	51	50.0	4	0
24	50	51	49	47	50	49.4	4	0.6
25	51	48	50	51	50	50.0	3	0.6
26	50	51	49	48	51	49.8		
27	50	48	47	49	50	48.8		
28	53	52	50	49	50	50.8		
29	53	53	50	50	54	52.0		
30	53	54	53	50	54	52.8		
31	54	51	54	54	54	53.4		
32	55	58	56	51	56	55.3		
33	53	55	54	49	53	52.8		
34	52	53	54	48	52	51.8		
35	52	52	50	48	51	50.6		
36	51	52	49	49	52	50.6		
37	49	52	49	50	50	50.0		
38	52	55	53	50	53	52.6		
39	50	52	52	49	49	50.4		
40	47	51	51	48	49	49.2		
Totals (1st 25 reels)						1261.4	120	22.4
Averages (1st 25 reels)						50.46	4.80	0.933

averages plotted within the above limits. Three of the reels shown are out of control. Two other failures to stay within the control limits occurred among the 40 reels.

Over a period of 6 months correction for lack of control of reel ranges and reel averages was made whenever assignable causes could be identified. At the end of the period, limits were recomputed, using data from Table II.

New limits for the control chart for cross-machine variation are 5.2 pounds per 1000 square feet and zero. The upper right portion of chart No. 1 shows that all reel ranges are in control.

New limits for machine direction variation are 52.10 and 49.30 pounds per 1000 square feet. The lower right portion of chart No. 1 shows that all reel averages are in control.

A count reveals that 23.5% of individual samples were outside of specifications during the first period but only 5.5% were outside during the latter period.

Interpretation: The control chart analysis of the data obtained before the start of the quality control system indicated that lack of control existed both across the machine and in the machine direction. This meant that unusual changes in basis weight occurred from time to time. The criterion for deciding what was unusual was the data itself. The control limits represented the weights within which the product might be kept if the process always did as well as it did on the average during short periods of time. Only reels which departed so far from the average that their basis weight could have been expected only a very small part of the time (27 times out of 10 thousand) showed up outside the limits. With such high certainty that trouble really existed (or that an excessive fluctuation had occurred) it was economical to try to find assignable causes for each failure to stay inside control limits.

The width of the limits indicated that the process certainly was not meeting the customer's specification of 50 pounds plus 5% even on the basis of reel averages. Until the process was brought under control, it was not possible to say whether the process was capable of meeting these specifications. Some confusion arises also from interpretation of the specifications. It should always be made clear what kind of a sample is to be taken and how many tests are to be averaged to determine conformance.

Recommendation: It was recommended that this control chart be kept at the paper machine and that all indications of lack of control either across the machine or in the machine direction be investigated and proper action to correct the causes be taken. Note that since this is an action chart it has to be of such design and has to be kept in such a location that it will be useful in machine control.

Result: The control charts after 6 months of quality

Table II. Basis Weight of Paperboard 6 Months After Start of Quality Control System

Pounds per 1000 Square Feet

Reel no.	*Front*	*Front middle*	*Middle*	*Back middle*	*Back*	*Reel average*	*Reel range*	*Moving range of averages*
41	52	51	50	51	51	51.0	2	0.6
42	51	50	50	50	51	50.4	1	0.6
43	52	52	51	52	50	51.4	2	1.0
44	52	50	51	49	50	50.4	3	1.0
45	51	51	50	50	51	50.6	1	0.2
46	52	50	50	49	49	49.8	3	0.8
47	49	52	49	48	52	50.0	4	0.2
48	51	50	50	48	50	49.8	3	0.2
49	51	49	50	49	48	49.4	3	0.4
50	50	50	50	50	48	49.6	2	0.2
51	50	50	50	50	49	49.8	1	0.2
52	50	50	49	49	53	50.2	4	0.4
53	51	49	51	50	52	50.6	3	0.4
54	52	52	52	49	52	51.4	3	0.8
55	52	50	50	51	54	51.4	4	0.0
56	51	50	50	50	51	50.4	1	1.0
57	52	50	52	51	51	51.2	2	0.8
58	52	50	51	48	51	50.4	4	0.8
59	51	50	52	50	51	50.8	2	0.4
60	53	52	51	50	52	51.6	3	0.8
61	52	51	50	50	52	51.0	2	0.6
62	53	52	51	50	51	51.4	3	0.2
63	52	53	52	51	52	52.0	2	0.6
64	53	51	51	51	53	51.8	2	0.2
65	52	51	50	50	52	51.0	2	0.8
66	52	50	52	52	52	51.6		
67	53	51	52	52	52	52.0		
68	52	51	52	52	52	51.8		
69	52	51	52	52	52	51.8		
70	51	52	52	52	52	51.8		
71	52	52	52	53	51	52.0		
72	52	50	50	50	52	50.8		
73	52	51	50	51	53	51.4		
74	51	51	50	49	51	50.4		
75	51	52	50	50	50	50.6		
76	51	51	51	52	52	51.4		
77	51	49	49	50	50	49.8		
78	50	51	51	50	52	50.8		
79	52	52	53	51	50	51.6		
80	50	50	50	50	51	50.2		
Totals (1st 25 reels)						1267.4	62	12.6
Averages (1st 25 reels)						50.70	2.48	0.525

control show perfect control within greatly narrowed limits. It appears that the process may be capable of maintaining the specified 50 pounds plus 5% on the basis of averages of five positions across the reel. No reels are above the specification, although six are less than 50 pounds.

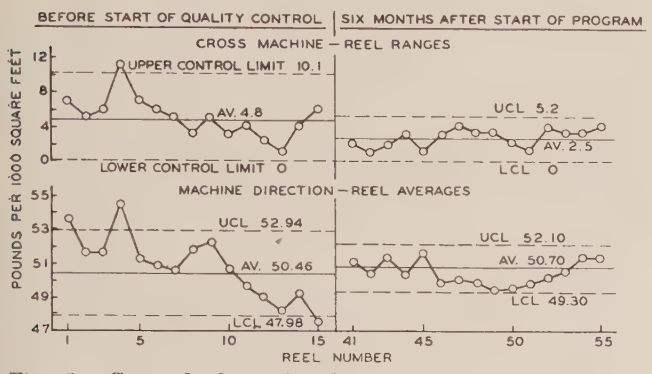

Fig. 1. Control chart for basis weight of paperboard samples from five positions across the sheet

This marked improvement in uniformity resulted in operating savings and in improved morale among the machine operators. It also increased the confidence of the user of the paperboard in the ability of the manufacturer to meet requirements. Overweight board had been causing 11% shrinkage in the square feet of board supplied under the contract. The improved control reduced this shrinkage to 2%. This was an item of considerable economy to the purchaser.

CASE STUDY II

Problem: Analyze and portray changes in quality or processing conditions as a guide for better control.

Data: Reel averages from Tables I and II are used in an example of analysis of product quality. These averages are accumulated in Table III. Also, 261

Table III. Method of Preparing Distribution Charts, Basis Weight of Paperboard

Column boundaries, lb./1000 sq. ft.	*Number of reels* — *Before quality control*	*After 6 months of control*
46.55–47.55	1	
47.55–48.55	1	
48.55–49.55	1111111	11
49.55–50.55	111111111111111	111111111111111
50.55–51.55	11111	1111111111111111
51.55–52.55	11111	1111111
52.55–53.55	1111	
53.55–54.55	1	
54.55–55.55	1	

consecutive freeness tests were made on samples taken from the headbox of a papermaking machine. These data, shown in Table IV, will be used to demonstrate the analysis of an in-process measurement.

The data in Table III will be considered first.

Analysis: A method of classifying measurements for the purpose of constructing frequency distribution charts is demonstrated in Table III (*3*). The usefulness of distribution studies arises from the fact that when the scale of measurements is divided into ordered classes of equal size and the number of observations falling within each class is counted, a definite pattern usually arises. Most variable measurements made in industry may be represented by a bell-shaped curve symmetrical about the average of the measurements. By comparing the shape of the pattern arising from any set of data with other data from the same source and with the normal curve, a great deal can be learned about what is going on in a process.

Table IV. Headbox Freeness Data—Paper Machine
(Read down columns in chronological order)[a]

7	6	7	4	16	7	12	20	17	16	11
7	9	14	8	21	10	17	21	17	18	13
6	14	6	4	22	9	15	22	14	18	13
5	11	7	6	13	9	15	23	17	20	11
14	10	4	6	17	10	15	20	22	21	20
7	7	5	10	12	12	14	27	20	20	24
11	7	3	7	12	13	12	18	17	19	15
5	8	3	9	10	15	15	17	16	20	19
7	9	9	9	13	17	13	12	19	22	11
4	8	4	12	13	17	15	14	18	21	12
10	9	11	11	16	12	21	14	21	13	12
4	11	8	10	20	14	16	12	23	13	Grand
8	12	9	16	17	10	15	14	14	14	average
15	7	17	11	21	13	18	14	15	11	13.0
7	8	1	14	12	13	18	16	19	11	
5	20	9	17	13	13	17	14	14	16	
12	13	5	22	20	13	21	15	17	11	
10	3	4	17	17	12	17	12	20	9	
8	1	3	14	22	13	17	11	18	10	
9	2	7	13	25	10	24	15	13	10	
8	1	3	9	26	16	29	16	14	14	
6	2	3	10	16	18	18	17	17	12	
9	3	3	16	23	15	22	15	18	13	
7	3	3	16	16	16	24	19	15	9	
7	2	2	21	13	9	21	15	17	11	

[a] Theory of runs indicates instability and data may be divided into logical groups at intervals indicated by horizontal marks.

The tally of reel average basis weights is shown separately for the 40 reels measured before the start of a quality control program and for the 40 reels measured 6 months later. This information is transferred to the left-hand portion of Fig. 2 as vertical columns equal in width to the measurement intervals of the table and of a height which represents the number of reels falling in each class. The relationship of these distributions to the specification maximum is shown. Comparison of the basis weight variation in the machine direction during the two periods is made easy by study of these distributions.

The data from Table IV have been represented in the

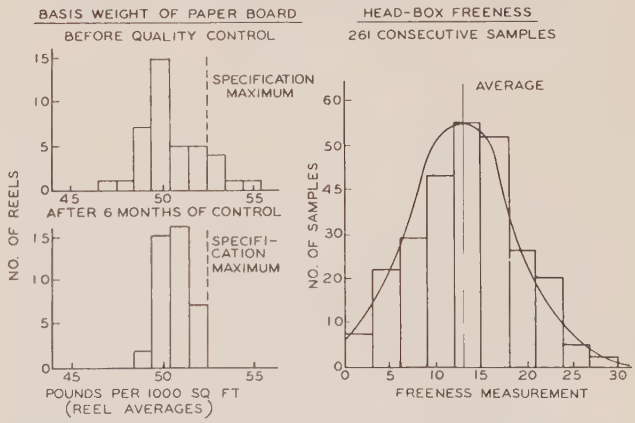

Fig. 2. Distribution charts of papermaking data

distribution chart at the right of Fig. 2. A normal distribution curve has been superimposed over the columns representing the number of samples in each headbox freeness class. The central axis of the curve is at the average of the 261 measurements. This shows there is not perfect conformance of the data with a normal distribution, and certain features of the observed

distribution may be pointed out. It may be seen that it is truncated at zero but it is even more significant that it is skewed to the high side of the measurement scale. This might not cause alarm because actual results are rarely perfectly normal and because statistical tests and the control chart method, in particular, are still valid when the distribution of individual measurements is quite a bit different from normal.

However, scanning of Table IV substantiates the suspicion that freeness is changing in an uncontrolled fashion. A count of consecutive series of measurements above or below the grand average discloses marked shifts in the level of freeness results from time to time. According to the theory of runs (*4, 5*), the long series of runs first on one side of the average and then the other indicates instability in the process. Therefore, the data were divided into four groups at what seemed to be logical points.

Distribution charts were prepared from the measurements falling into each of these periods. These charts are shown in Fig. 3. The scale has been rotated 90° from the usual position so that relation of the distribution chart to control chart limits could be demonstrated. For the first three periods, enough data were available to permit drawing of smoothed distribution curves in addition to the bar charts. These are all freehand curves but it is apparent that within the two middle periods, at least, something approaching a normal distribution was present. However, although the curves are similar, the average shifted from period to period.

These distribution charts require waiting a considerable time for data to accumulate. Therefore, although they are excellent for portraying what has happened, they are less useful than the control chart in giving immediate warning of disturbing factors. Control chart limits could be computed from the data of a period which had desirable freeness characteristics, say the second period, and extended for plotting of future results. Then, samples of excessively variable freeness would be detected at once, while the chance of discovering assignable causes was best.

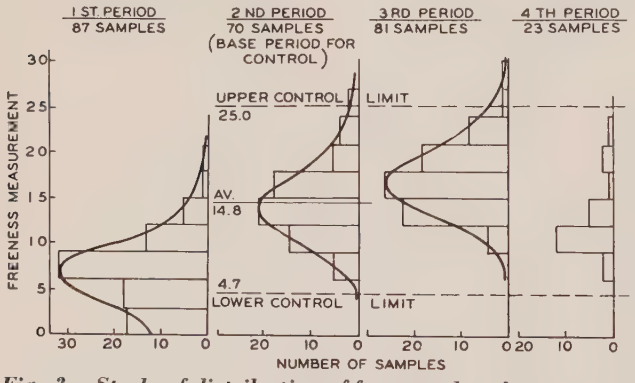

Fig. 3. Study of distribution of freeness data from a paper mill

To obtain the limits shown on the figure, 15 groups of five consecutive measurements from the second period were used. Since the distribution curves are for individual freeness measurements, and it would be desirable to control the process on the basis of these single samples, control chart limits for individual values are shown. Using the grand average freeness for the second period and the average range of the 15 subgroups, the upper control limit was found to be 25.0 and the lower control limit, 4.7. The necessary computations are shown in the Appendix. Two measurements were outside these limits in the third period but all of the first 23 samples in the fourth period were within the limits.

Interpretation: Examination of Table III and the left

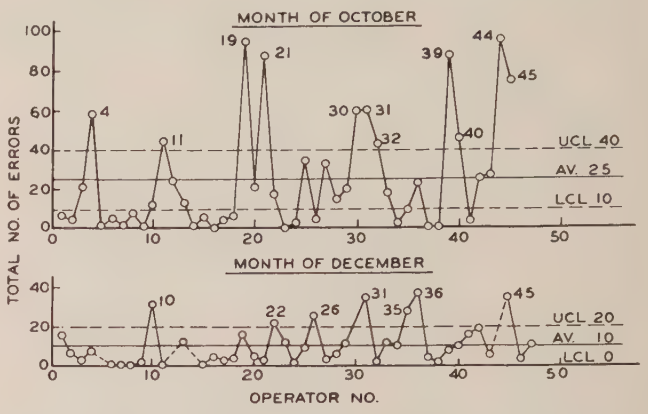

Fig. 4. Control chart of errors made by paper sorters total number of errors made by individual sorters determined by re-inspection

side of Fig. 2 makes it obvious that the distribution of reel average basis weights has become narrower (the product is more uniform). It is apparent, also, that the grand average basis weight has become slightly higher. At the same time, the process has been brought into conformance with the specification maximum.

Although this improvement was brought about by application of control charts, some basis for action to improve the process could have been provided by study of the original distribution chart. Its width and nonsymmetrical shape indicated that the process was too variable to meet the specification and that some disturbing factors were at work. Possibly, critical analysis of these characteristics of the distribution could have led, within the same 6-month period, to identification and correction of the causes of variation. However, this provides a less direct method for process control than the control chart.

It is not known exactly what significance may be attached to the changes in freeness levels at intervals of about 80 measurements in Table IV. However, this shifting in level of freeness, brought out so clearly in Fig. 3, warns that results should be charted in some systematic manner and studied to determine causes. Study of the series of distribution charts provided clues to the kind of thing that had happened. Different significance was attached to shifts in level and to changes in shape of the curve. However, as has been pointed out, the control chart would have pin-pointed the time of occurrence of trouble with more precision.

It was necessary to come to some decision regarding acceptable limits of freeness and base future comparisons on the standard limits. With close attention to the controls, it is possible that the good results observed at the start of period four might be continued indefinitely.

Recommendation: It was recommended that distribution charts be used from time to time to supplement control charts for control of basis weight of paperboard. In particular, this method of charting results was recommended for presentation to management.

For improvement in the uniformity of headbox freeness it was recommended that the control chart for individual tests be continued. It was also suggested that frequency charts be used from time to time to summarize progress.

Result: The principal result of the use of distribution charts to analyze the basis weight of paperboard was to represent the problem by means of readily understood symbols. At the start, the extent of the problem was most clearly visualized by this means. At the conclusion of the work, the degree of improvement was demonstrated effectively. As a means of reporting results to people unfamiliar with control charts, the diagrams of Fig. 2 are superior, perhaps, to the charts of Fig. 1.

The result of the analysis of the freeness data by these statistical means was to make the headbox freeness much more uniform and to make it possible to maintain freeness within the narrower limits at its optimum level.

CASE STUDY III

Problem: Comparison of testers to determine their ability to reproduce their own results and to check those of others. Also to determine the number of tests required to check within certain limits.

Data: A large sample of paper was cut into twenty 3-inch squares which were thoroughly mixed and divided between the two testers. Each tester used the same method for obtaining ten greaseproof test results as shown in Table V.

Table V. Data on Greaseproof Test on Paper

All Figures in Seconds

	Tester A	*Tester B*	
	960	1360	
	270	440	
	300	1400	
	210	1740	
	1800	1100	
	660	900	
	1800	320	
	1020	680	
	480	1800	
	1800	1400	
Totals	9300	11140	
Averages	930	1114	Difference = 184

Analysis: The first two steps in the analysis are indicated in the table: total each column and obtain its average. The difference between the average greaseproof test results for tester A and tester B is shown also.

One of the first questions that must be answered concerning these data is whether the variation among the ten tests performed by tester A is sufficiently like the variation among the ten results by tester B to make a realistic comparison between the two possible. If one has excessive variation compared to that of the other, the later comparisons that we may wish to make between the testers will be of questionable validity.

In order to answer the question concerning the comparableness of the variation within the two columns, it is necessary to compute a standard measure of variability known as "variance" for each (*3*, *6*). The ratio of the variances is then used to determine whether one is significantly larger than the other. All the necessary computations may be found in the Appendix.

If the few results that are available for each tester are thought of as parts of frequency distributions similar to those discussed in the previous case study, the problem under consideration may be looked upon as a comparison of the spread of two distribution curves. Obviously, if one tester's results may be portrayed by a very narrow, peaked curve and the other's by an extremely wide, flat curve, the two sets of results are different. The degree of difference in spread that is significant is defined precisely by statistical laws. The variance ratio test provides a systematic method for deciding whether the difference between the two sets of data is larger than could be expected normally.

The variance for tester A is 434,000 and for tester B it is 267,293. The ratio between these two variances is 1.627. This is known as the F ratio.

This ratio is compared with the theoretical ratio in a statistical table (see Table III in the Appendix of reference (*6*)). The methods of performing this and other tests in this case study are to be found also in reference (*6*). In this instance it is possible to conclude that because the ratio is less than the appropriate figure in the tables, the evidence is so slight that the variation in A's test is greater than that in B's that we can conclude that there is no significant difference.

Since there is no significant difference, it is possible to pool the two variances to obtain a common figure which will represent the variation in the greaseproof test attributable to one tester. The pooled variance is 350,647.

In order to proceed with the comparison of the test results it is necessary to obtain the standard deviation of the test which is equal to the square root of the pooled variance, or 592 seconds. With this figure available, it is possible to answer another question, whether the two average results are significantly different.

In order to answer this question, advantage is taken again of what is known about how data such as these normally distribute themselves.

If the averages are not far enough apart to be considered different it is because the two sets of results have essentially the same distribution. On the other hand, the averages will be considered different if it is shown that it is likely that they came from different distributions.

The statistical test used to make this decision is called the t test. It relies on the fact that the spread of a normal distribution curve such as that shown in the right half of Fig. 2 may be described in terms of standard deviation units. Plus and minus one standard deviation includes 68% of the area under the curve; plus and minus two standard deviations includes 95%; and plus and minus three standard deviations includes 99.7% (or practically all) of the area under the curve.

The limiting number of standard deviations which is normally found between averages of results coming from the same distribution is governed by statistical laws. The t test tells how probable it is that the observed difference is indeed no larger than could have been expected.

The t value for the two testers' averages is 0.693.

As with the ratio of variances computed before, this result is also compared to a tabular value (see Table I, Appendix, reference (*6*)). The computed result is so small compared to the tabular value that we may

state that there is no significant difference between the two average results.

It may be of interest to note how large a difference between two such averages of ten measurements would have to be in order to be considered significant. The value of interest, called the Least Significant Difference, depends on the relationships just described, except that a t value is chosen from the table and the permissible difference is then computed. For averages of ten tests each, the least significant difference is 556 seconds.

A final question that may be asked is how many tests must be included in each average if we want to be sure that an observed difference as small as, say, 100 seconds is actually real. The number of tests required in each average is 309. In this instance both t and the permissible difference were selected and the unknown number of tests computed.

It is necessary to qualify the statements made in this section by pointing out that the significance tables for both F and t were used in such a way that the probability of our being in error is only 5% or less.

Interpretation: The fact that the F test for differences in variability and the t test for differences in average level both showed no significant difference to exist means that the work of the two testers is equally precise and accurate. In other words, each can reproduce his own results equally well and the two are able to check one another as well as could be expected considering their own reproducibility. However, this does not mean that the test is satisfactory. Actually, the size of the difference required for significance between averages of 10 tests each shows that the test is not very discriminating. Furthermore, the number of tests which must be averaged to obtain enough precision to tell differences as small as 100 seconds, which it would be desirable to be able to do, is prohibitive.

Recommendations: Obviously, increasing the number of pieces tested by a reasonable amount will help some. The improvement is in proportion to the inverse of the square root of the number of tests. The reason for the poor check between individual test results should be investigated. A great deal of this difference may be ascribed to the paper itself and for that reason it may be impossible to improve the precision of this test to any great extent. However, part of the difference is due to human error and every effort should be made to reduce the error due to sources of this type to a minimum. The greater care and skill the tester uses in preparing the specimens, performing the test, and reading and recording results, the better the precision will be. The more closely the method is standardized, the more capable the testers will be of checking one another's results.

Result: The result of the greater care exercised in performance of the test was a detectable improvement in its precision. However, the inherent variability of the paper itself leaves much to be desired. It is of interest to note here the comments of one paper laboratory chemist regarding the problems involved in the routine testing of paper.

"One of the cancerous evils of routine paper testing is the spirit of simple mechanical repetition which may be created by the monotony and nature of paper testing done in ignorance or negligence of the significance thereof. Periodically it is therefore not only wise to review the potential value which may be obtained from such work, but also to investigate whether the reliability, reproducibility and efficiency of the technique used are related to the significance that is given to the results" (*7*).

CASE STUDY IV

Problem: Reduction in the number of errors made by paper sorters.

Data: The total number of errors made by each of the paper sorters employed in a certain mill was determined for the month of October by a process of reinspection. Similar data were obtained for December of the same year, after the information obtained from the original study had been used as a basis of a program to improve operator attention and skill. The data from both periods are given in Table VI.

Table VI. Total Number of Errors Made By Paper Sorters Determined By Reinspection

Sorter no.	*October*	*December*	*Sorter no.*	*October*	*December*
1	7	16	25	35	8
2	4	5	26	4	26
3	22	2	27	32	3
4	58	7	28	15	5
5	2	..	29	20	10
6	6	0	30	60	..
7	2	0	31	60	35
8	9	0	32	43	1
9	1	1	33	18	11
10	13	31	34	2	9
11	45	0	35	10	26
12	24	..	36	23	37
13	13	11	37	0	4
14	1	..	38	0	1
15	5	0	39	87	7
16	0	3	40	46	9
17	5	2	41	3	17
18	7	3	42	25	19
19	95	17	43	26	6
20	21	4	44	96	..
21	87	2	45	74	35
22	17	21	46	..	4
23	0	10	47	..	11
24	2	1			
			Totals	1125	420
			Averages	25.00	10.00

Analysis: Since this problem involves a count rather than a measurement as have the preceding case studies, a different set of statistical laws underlie the behavior of these data. However, the technique used in the solution is a control chart (*2*) very simple to set up and to use and interpret.

The control charts for the two periods, before and after action based on the first period, are shown in Fig. 4. The upper part of the chart, showing the October results, illustrates the high average error rate and the frequently excessive number of errors made by individual sorters.

The control limits which provide a rational basis for deciding just how much an individual's error rate may diverge from the average before it may be considered important are 40 errors for the upper limit and 10 errors for the lower limit.

The total number of errors made by each operator during October is plotted between the dotted control limits on Fig. 4. The average rate of error has been shown as a solid line.

At the bottom of the chart is a similar picture of the

Table VII. Data on Water Penetration Test on Paper, Averages and Ranges of Eight Tests Each in Seconds

Sample no.	Operator A		Operator B		Operator C		Operator D		Totals
	Average	Range	Average	Range	Average	Range	Average	Range	Averages
1	29	2	23	10	27	2	26	6	105
2	33	5	23	6	29	5	28	5	113
3	55	3	46	11	48	11	57	17	206
4	50	3	47	15	46	7	53	5	196
5	53	6	43	8	42	5	48	5	186
6	44	4	46	10	44	9	41	7	175
7	44	7	36	6	37	6	42	10	159
8	46	4	42	11	39	5	44	5	171
Totals	354	34	306	77	312	50	339	60	1311
Grand Total Range									221

count of errors made in December. Limits for December were 20 errors for the upper and 0 errors for the lower limit.

Interpretation: It will be noted that this control chart technique uses the average error rate of the individual and his co-workers to determine the standard by which the adequacy of all workers may be judged.

In December, because careful use of the October information had been made, the standard of adequacy is much stricter than in October. It is interesting, moreover, to note that even though the average error was reduced from 25 to 10 per worker and the limits consequently cut in half, from 40 to 20 errors, conformance is much better than in October. During the earlier period, 11 individuals had error rates greater than the upper limit. In December, only seven sorters were "out of control" and none of these were as high as the October limit. It is also interesting to note that only two operators, Nos. 31 and 45, who were out of control in October were still out of control in December. Even for these two, the error rate had been cut in half!

This is one of those situations in which the action taken on the basis of the control chart depends upon a sound managerial approach to psychology. It would be most unwise, for example, to post these results or publicize them in such a way as to harm the individual worker's dignity. However, their public use without identifying an individual's score, or on a shift basis to encourage competition in the plant, would be useful under some conditions. The improvement in the average score and the relative limits from month to month are suitable material for campaign emphasis. The ever decreasing top limit might be set up as a kind of bogie. However, supervisors should take care not to make comparisons within the bogie since the limits represent a range within which the scores of even careful sorters may fall. Note, for example, that the operators who made no errors during October made 3, 10, 4, and 1 errors, respectively, in December and that zeros in December followed October errors of 6, 2, 9, 45, and 5.

When an operator's error exceeds the limits it is the proper subject of conference between the worker and supervisor. Although group psychology will be active in pulling the over-all average error down, the elimination of most extreme individual fluctuations will probably depend on careful encouragement and training of individuals. One of the greatest advantages of statistical methods in industry is that they supply many extremely helpful guides to improvement in industrial relations.

Action Taken: The poor record of October made clear the advisability of taking adequate steps to reduce the number of errors. Operators having bad scores were given personal attention of the supervisors. A campaign was begun to improve the general record of workers in the area. To guide management in conduct of this campaign and to portray its results, control charts were maintained regularly. Other angles of the situation, in addition to the ones reported here, were investigated. For example, it was found that the number of errors correlated highly but inversely with the amount of daily production per sorter. The fact that slow workers were also careless workers led to intensification of the training campaign, more careful screening of workers, and even to reassignment of workers.

Result: The improvement from October to December is quite easy to see. There was room for even further improvement. For that reason, and because constant vigilance is required, as it is in so many activities, this kind of analysis is returned to time and again as a means of checking on performance.

CASE STUDY V

Problem: Investigation of paper testing technique to identify factors which may be improved.

Data: A group of eight samples of paper was selected at random from a series which had been tested during several preceding months. Papers were selected purposely for which the previous tests had varied over the usual range. The selection of old samples was intended also to eliminate the effect of aging during the 10-day period in which the new series of tests was made. The selected paper samples were divided into four parts and each part given to a different operator. Instructions were given to condition the paper as usual and make a number of tests using standard procedures. The results for the water penetration test are given in Table VII.

Table VIII. Water Penetration Test on Paper Variance Table

Source of variation	Sums of squares	Degrees of freedom	Mean squares	"F" ratio	Probability of significance
Samples	19,097.75	7	2,728.25	23.7	99.9%
Operators	2,766.00	24	115.25	19.7	99.9%
Test	1,312.64	224	5.86		
Totals	23,176.39	255			

Values are given in seconds for the average and range of eight tests on each sample by each of the four operators.

Analysis: The column and row totals of the test averages are shown in the table as well as the totals of the range columns and the grand total range. All of these totals will be useful in further analysis of the data.

The orderly arrangement of this experiment suggests the "analysis of variance" (*6*) as a means of analysis. Ideally, we should like to start on this analysis having the benefit of all the original individual test values. However, the individual measurements were not included in the original report on this work and are now buried in some analyst's notebook, inaccessible for purposes of this discussion. The comment may be made, however, that the unfortunate "burial" of useful data occurs all too often and that the science of paper testing would benefit by preservation of *all* pertinent data in the formal report of this sort of investigation. The fact that ranges of sets of tests were reported mitigates the shortcomings of these data somewhat.

It has been shown in case study III, using data from a greaseproof test, how to compare the work of two testers. In the present case study, the analysis of variance is used to compare a larger number of testers. Also, the problem is extended to include analysis of the ability of the group of testers to discriminate among several different materials, in this case samples of different kinds of paper.

The computations used in "analysis of variance" involve comparison of variation in parts of the data arranged in different ways. The arrangement is designed to include or exclude specific factors responsible for variation. The procedure may be visualized in a way which makes sense operationally by thinking of the values obtained by varying a factor as being compared on the basis of the variation within all the measurements making up those values. If the variation added by experimentally varying some factor is not significantly greater than the random variation which may be expected, no important effect may be claimed for that factor.

The analysis of variance is simply a statistical device for separating the total variation in the data according to its sources. In the example, this means determining how much variation is due to the ability of individual operators to reproduce their own results, how much to ability of operators to check one another, and how much is due to the actual differences between the samples being tested. For simplicity, these sources of variation are described as the test, the operators, and the samples, respectively.

Comparisons are made successively to determine whether the test is precise enough so that differences among operators may be recognized and whether operators check well enough so that differences among the samples may be considered significant. The same kind of a variance ratio test used in the earlier example is employed in making these comparisons. The orderly arrangement of the data makes the choice of which ratios to compute quite a simple matter.

The principles of the *t* test which are already familiar, may be used later to separate either operators or samples into groups which are significantly different from group to group although the individuals within the groups may not be clearly distinguishable from one another.

The averages of Table VII are used in the main analysis of variance and an additional term, the variance within an operator's tests is computed from the range information of Table VII (*2*).

The results of computations which are given in detail in the Appendix may be used to analyze the sources of variation in water penetration by summarizing the information in a variance table, Table VIII.

The mean squares (variances) are obtained by dividing the computed sums of squares by the appropriate degrees of freedom. In the instance of test variation the procedure has been reversed since the mean square was computed directly. The *F* ratios, or operator mean square divided by test mean square and sample mean square divided by operator mean square, indicate that there is an extremely high probability of significant differences between operators as well as between samples.

It is of interest next, to determine which operators are different from the others and to classify the samples in groups having similar water penetration properties.

To differentiate among operators, the least significant difference required may be computed. If all available data are to be averaged, the least significant difference is 0.84.

Grouping averages of similar operators, including within parentheses those whose average results vary less than the *Lsd:*

(Operator B and C)	(Operator D and A)
(Av. 38.25 and 39.00)	(Av. 42.38 and 44.25)

The least significant difference between samples, using the grand average of all the data for each sample in Tables VII and VIII is computed as 5.24 seconds.

Grouping in the same parentheses similar samples, or all those for which successive differences do not exceed the *Lsd:*

(Sample	1	2)	(7	8	6	5	4	3)
Av.	(26.5	28.25)	(39.75	42.75	43.75	46.50	49.00	51.50)

It should be noted that by an extension of the method used here for comparing averages (*8*) further comparison of the averages in the second, larger group may be made. Thus, sample 7 may not be distinguished from samples 8 or 6 but is different from samples 5, 4, and 3. Sample 8 may not be distinguished from samples 7, 6, or 5, but is different from samples 4 and 3. Sample 6 is not different from samples 7, 8, 5, and 4 but is different from sample 3. Samples 5, 4, and 3 are not distinguishable.

It is not commonly the practice to average so much data in making comparisons between samples. If the amount of testing to be done on a routine basis is limited to a reasonable amount, the size of the difference required for significance will be much larger than the 5.24 points used in the foregoing comparisons.

For example, if economy dictates that no more than eight test pieces may be used and all tests are performed by one operator, the *Lsd* is found to be 10.5 seconds.

It would be much better, from the standpoint of precision to average the results of fewer tests each by two or more operators.

Interpretation: Operator B and C obtained results that checked closely and operator D's results checked closely with operator A's. However, the cross-check

between the two groups is so poor that it is highly improbable that neither nonuniformity of the paper nor the ability of operators to reproduce their own results is responsible. This is an unsatisfactory state of affairs because such disagreement indicates inefficient testing. The difference between the operators, being the largest source of variation, should receive greatest emphasis in efforts to improve the test. There appear to be at least two causes for such poor results. Under the classification of efficient mechanical manipulation, one must include both the proper conditioning of the paper and the proper mechanics of operation. The first important premise for satisfactory testing of paper in a manner that will be reproducible must be sufficiently long conditioning at constant temperature and humidity. The second premise is that all tests must be made by exactly the same technique.

In the case of this particular test the second premise may not have been fulfilled because the application of the sugar dye mixture or reading the end point varied between operators.

Recommendations: In order to assure a better performance of the test in the future, a conference was held in which the proper testing procedure was demonstrated and agreed upon. This resulted in adoption of a technique for more uniform application of sugar dye and a more careful specification of how to determine end point.

Result: As a result of this analysis, the ensuing discussion, and the efforts of operators to improve the test, measurable progress has been made in improving the ability of operators to check each other's work. This raises the level of confidence that may be placed in the test.

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APPENDIX

A. Comparison of Cross-Machine and Machine Direction Variation in Basis Weight of Paper

Computations for Fig. 1

1. Before start of quality control system

Control limits for cross-machine variation:

$D_3\bar{R}$ and $D_4\bar{R}$, where D_3 and D_4 are factors obtained from a table in reference (*2*) and $\bar{R}$ is the average reel range from Table I.

$$D_3\bar{R} = 0 \times \bar{R} = 0$$
$$D_4\bar{R} = 2.114 \times 4.80 = 10.1 \text{ pounds per 1000 square feet}$$

Control limits for machine direction variation:

$\bar{\bar{X}} \pm A_2\bar{R}\sqrt{2}$, where $\bar{\bar{X}}$ is the grand average and $\bar{R}$ is the average moving range of averages from Table I and A_2 is a factor from a table in reference (*2*)

$$\bar{\bar{X}} \pm A_2\bar{R}\sqrt{2} = 50.46 \pm 1.88 \times 0.933 \times 1.414$$
$$= 52.94 \text{ and } 47.98 \text{ pounds per 1000 square feet}$$

2. Six months after start of quality control system

Control limits for cross-machine variation:

$$D_3\bar{R} = 0 \times 2.48 = 0$$
$$D_4\bar{R} = 2.114 \times 2.48 = 5.2 \text{ pounds per 1000 square feet}$$

where $\bar{R}$ is the average reel range from Table II.

Control limits for machine direction variation:

$$\bar{\bar{X}} \pm A_2\bar{R}\sqrt{2} = 50.70 \pm 1.88 \times 0.525 \times 1.414$$
$$= 52.10 \text{ and } 49.30 \text{ pounds per 1000 square feet}$$

where $\bar{\bar{X}}$ is the grand average and $\bar{R}$ is the average moving range of averages from Table II.

B. Analysis of Freeness at the Headbox of a Paper-making Machine

Computations for Fig. 3

Control limits for individual freeness values based on second period:

$$\bar{\bar{X}} \pm A_2\bar{R}\sqrt{n} = 14.83 \pm 0.577 \times 7.86 \times \sqrt{5}$$
$$= 25.0 \text{ and } 4.7 \text{ freeness}$$

C. Comparison of Tester Reproducibility and Ability to Check Work of Others—Greaseproof Test

Computations for Case Study III

Divide all original values in Table V by 10 and subtract 30 to simplify computation.

1. Tester A variance $(\sigma_A^2) = \left[\Sigma X^2 - \frac{(\Sigma X)^2}{n}\right] \times \frac{10^2}{n-1}$

$$= \left[\Sigma(66^2 + (-3)^2 + \ldots + 150^2) - \frac{630^2}{10}\right] \times \frac{100}{9}$$
$$= 434{,}000$$

where Σ = summation of; X = an individual measurement; and n = number of measurements in the set.

2. Tester B variance (σ_B^2)

$$= \left[\Sigma(106^2 + 14^2 + \ldots + 110^2) - \frac{814^2}{10}\right] \times \frac{100}{9}$$
$$= 267{,}293$$

3. Variance ratio (F)
$= \sigma_A^2/\sigma_B^2 = 434{,}000/267{,}293$
$= 1.627$ with $10 - 1/10 - 1$ degrees of freedom

4. Pooled tester variance $(\sigma_A^2 + \sigma_B^2) = \frac{434{,}000 + 267{,}293}{2}$
$= 350{,}647$

5. Standard deviation of test $(\sigma) = \sqrt{350{,}647}$
$= 592$ seconds

6. t test for significance of difference between tester averages

$$t = \frac{|\bar{X}_A - \bar{X}_B|}{\sigma}\sqrt{\frac{n_1 \times n_2}{n_1 + n_2}}$$

or, since the sets are of equal size,

$$t = |\bar{X}_A - \bar{X}_B| / \frac{\sigma\sqrt{2}}{\sqrt{n}}$$

$$= 184 / \frac{592\sqrt{2}}{\sqrt{10}}$$
$= 0.693$ with $20 - 2$ degrees of freedom

where $|\bar{X}_A - \bar{X}_B|$ = the absolute difference between the two averages; n_1 and n_2 are the number of measurements in the respective averages; and the term $\frac{\sigma\sqrt{2}}{\sqrt{n}}$ = the standard deviation of the difference.

7. Least significant difference between averages of 10 tests

$$(Lsd) = t\frac{\sigma\sqrt{2}}{\sqrt{n}} = 2.10 \times 592 \times \sqrt{2}/\sqrt{10} = 556 \text{ seconds}$$

where t is obtained from the table of t, see Table I in the appendix of reference (*6*).

8. Number of tests in each average to be 95% certain that an observed difference of 100 seconds is real (n) $= \left(\frac{t\sigma\sqrt{2}}{d}\right)^2$

$$= (2.10 \times 592 \times \sqrt{2}/100)^2$$
$$= 309$$

where d is the required difference.

D. Control of Number of Errors Made by Paper Sorters

Computations for Fig. 4

Control limits for total number of errors made by individual sorters:

1. October data:

$$\bar{p}n \pm 3\sqrt{\bar{p}n}$$

where $\bar{p}n$ is the average number of errors per sorter

$$\bar{p}n \pm 3\sqrt{\bar{p}n} = 25.0 \pm 3\sqrt{25}$$
$$= 40 \text{ and } 10 \text{ errors}$$

2. December data:

$$\bar{p}n \pm 3\sqrt{\bar{p}n} = 10.0 \pm 3\sqrt{10}$$
$$= 20 \text{ and } 0 \text{ errors}$$

E. Investigation of Paper Testing Technique—Water Penetration Test

Computations for Case Study V

Note that values in Table VII are averages and ranges of eight tests each. To simplify computation, 40 was subtracted from each average.

1. Analysis of variance for Table VII averages

Since these are *averages*, their use in the analysis is equivalent to using *totals* which have been divided by 8.

(a) Term for operators $= [(-11)^2 + (-17)^2 + \ldots + 4^2]8^2/8 = 22{,}104$
(b) Term for samples $= [(-55)^2 + (-47)^2 + \ldots + 11^2]8^2/8 \times 4 = 19{,}338$
(c) Term for grand total $= 31^2 \times 8^2/8 \times 4 \times 8 = 240.25$
Sums of squares for samples $= (2) - (3) = 19{,}097.75$, $(8-1)$ D.F.
Sums of squares for operators $= (1) - (2) = 2{,}766.00$, $8(4-1)$ D.F.

2. Test variance from Table VII ranges

Variance (mean square) for test $(\sigma_T^2) = (\bar{R}/d_2)^2 = \left(\frac{221}{32}/2.85\right)^2 = 5.86$

where $\bar{R}$ is the grand average range and d_2 is a factor for the number of individual tests in the sets from which the ranges were computed. (See table of control chart factors in reference (*2*)).

3. Least significant difference (Lsd) among operators

$$Lsd = t\sigma_T\sqrt{2}/\sqrt{n} = 1.96 \times \sqrt{5.86} \times 1.414/\sqrt{64} = 0.84 \text{ second}$$

4. Least significant difference among samples

Variance for test $(\sigma_T^2) = 5.86$
Variance for operator $(\sigma_O^2) = (115.25 - 5.86)/8 = 13.67$
Variance of average by four operators, eight tests each $= (13.67/4) + (5.86/8 \times 4) = 3.60$
$Lsd = \sqrt{2}t\sigma/\sqrt{n} = 1.414 \times 1.96 \times \sqrt{3.60} = 5.24$ seconds
Variance of average of eight tests by one operator $= 13.67 + 5.86/8 = 14.40$
$Lsd = 1.414 \times 1.96 \times \sqrt{14.40} = 10.5$ seconds

Received Jan. 25, 1951. Presented at the Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 19–22, 1951.

Slotted Screen Plates for Pulp and Paper Mills

HENRY W. DOWNS, JR.

A brief description of the development, design, and installation of slotted screen plates is given.

Slotted screen plates may be divided into two broad categories: namely (1) flat plates for flat diaphragm screens and (2) curved plates for rotary screens.

Inasmuch as all screening was originally done on flat screens a few words on the evolution of the flat screen plate may be in order.

Very early metal screen plates were made from rolled yellow brass sheets which were supplanted by cast acid-resisting bronze plates due to their somewhat better corrosion resisting qualities.

For many years cast acid-resisting bronze was the best available material but in the light of present-day experience was far from satisfactory in many mills due to its relatively short life. In fact, in some mills the life of a bronze plate was so short that a solution simply had to be found.

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With the development of chromium plating and its application to screen plates a vast improvement was made. The life of a chromium-plated bronze plate is usually at least double, and very often many times that of an unplated plate. Wear of the slots is a negligible factor with chromium-plated plates which means they maintain their gage until failure of the plating results from galvanic action or corrosion of the base metal. Galvanic action may result if the base metals are exposed to the stock as a result of a break in the plating surface, due to a blow or due to porosity, and providing the stock conditions are right for this action. This usually results in holes eaten through the slot.

Exhaustive investigation would indicate that failure due to corrosion of the base metal is a result of the stock seeping through the plating and attacking the bronze base metal and the products of corrosion forcing off the chromium. There is no direct attack on the chromium itself.

In an effort to get better coverage of chromium on the plates the open back design was developed, particularly

for plates having 7 or more slots per inch, which consists of milling away part of every other rib on the underside of the plate. The open back construction had a further advantage from the users point of view. Opening up the back reduced plugging on the underside resulting in freer, easier release of the stock underneath and increasing screening capacity. Thus the adoption of chromium plating was a great step forward in screen plate design and development. In some of the sulphite mills, however, even chromium plated plates were not good enough.

The development of stainless metals opened up a whole new field for development for a better plate. The stainless steel used is type 303, free machining quality, or type 304. Type 316 may be preferable but it is extremely difficult to slot, especially in fine gages, and would greatly increase the cost of the finished plate. Furthermore, inasmuch as no type 303 or 304 stainless steel plates have failed from slot wear and fatigue tests have shown type 316 to be little if any better than type 304, there would seem to be no justification for using type 316. Monel was tried and was very satisfactory mechanically but in many cases was entirely unsatisfactory from a corrosion resistance point of view. This led to stainless steel plates.

A plate can be manufactured from solid stainless steel, in fact some are, but due to a greater material cost they are very expensive compared with the thin sectional plate, and of these the fabricated plate as manufactured by ourselves is the one which we will describe.

This consists of a stainless steel top sheet riveted to a Monel frame with Inconel rivets. At first all stainless steel construction was used but the frames cracked and the rivets failed.

To overcome this the frame was made of Monel and Monel rivets used. But the rivets failed due to corrosion. The Monel frames are also attacked but usually so slowly that no trouble is caused.

By using Inconel rivets the rivet problem has been largely overcome.

Some mills are using Inconel screen plates which are similar in construction to the stainless steel ones except that an Inconel top sheet is used instead of stainless steel. These have a corrosion resistance equal to stainless steel and a higher fatigue resistance. If any mill has a salt water corrosion problem Inconel has been found to be far superior to chrome nickel steel.

Flat screen plates can be classified in order of quality as follows: (1) Inconel; (2) stainless steel; (3a) chrome-plated bronze; (3b) nickel-plated bronze for unbleached sulphate, and (4) unplated bronze. The above classification is based on life expectancy either from mechanical superiority or ability to resist corrosion, or a combination of both. No real figures can be given for life of screen plates as they vary so widely from mill to mill according to type of stock being screened and mill conditions. Unplated plates may only run 4 or 5 months in some mills or several years in others. Plated plates may last 8 or 10 months or many years according to mill conditions. The life of stainless steel and Inconel seems to be indefinitely long except for mechanical failure. No stainless or Inconel plates have failed to date due to corrosion.

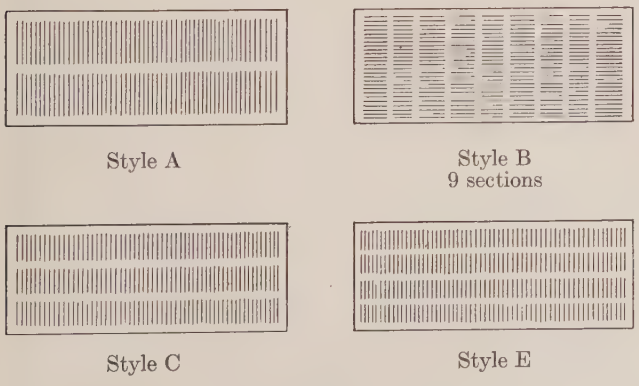

Fig. 1

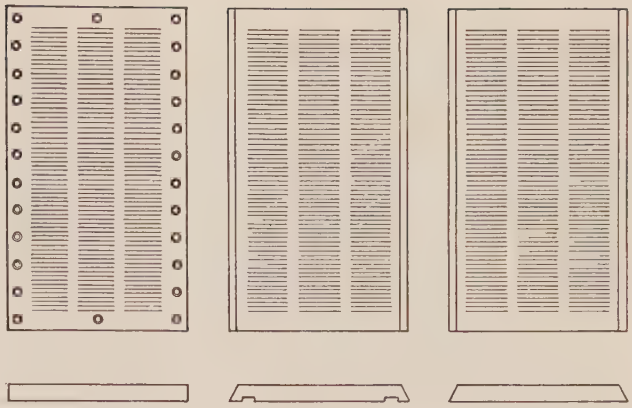

Fig. 2

Early type plates were made style A—4 slots per inch. This type of plate is still used by board mills, Fig. 1.

In order to increase screening capacity the number of slots per inch were gradually increased until today some of the Scandinavian mills are using 10 slots per inch although the largest number of slots per inch used in Canada are 8 slots per inch. With the increase in the number of slots per inch they had to be made shorter so that they would be stiff enough to prevent breathing and consequent dirt passing. This led to the development of style C and E plates, Fig. 1.

Today the standard types of plates are somewhat as follows:

Board Mills	Style A	4 or 5 slots per inch
Sulphate Mills	Style C	5 slots per inch
	Style E	6 slots per inch
Sulphite Mills	Style C	6 or 8 slots per inch
	Style E	8 slots per inch
Tailing screen for paper machine screens	Style B	9 Rows of slots, 4 slots per inch
Screens equipped with scraper	Style B	

Typical examples of gages of slot used in Canada are as follows:

Board mills.....0.020, 0.024, or 0.026 inch
Sulphate mills.....0.010, 0.012, and 0.014 inch with main screening carried out on 0.012-inch cut plates
Sulphite mills.....0.006 or 0.007, 0.008, and 0.009 inch with main screening carried out on 0.008-inch cut plates
Tailing screens for Bird paper machines screens on newsprint.....0.013 inch

If the screen plates are to be made of stainless steel or Inconel in which the slots do not wear, it is advisable to use as coarse a slot as mill operating condition will allow and still give acceptable pulp (usually at least 0.001 inch coarser than unplated bronze plates), giving greater screening capacity. The screening capacity of plates varies widely from mill to mill according to the kind of pulp being screened, kind of screen used, condition of the screen, type of plate, number of slots and gage of slot.

There are three general methods of fastening flat screen plates in Canada, Fig. 2.

1. Plates with holes drilled for wood screws all around the edges. This type seals well but is very slow to change.

2. Beveled and grooved for Union fastener. This type seals exceptionally well, can be more rapidly changed than the screwed type and has the further advantage that the Union-type fastener can be adapted to screens built for the screwed or square-edge drilled plate.

3. Beveled 28° for Witham and similar type fasteners. This type seals well if the plates are carefully installed and is by far the most rapid type to change, but in operation does not compare in reliability to the Union-type fastener. Its only real advantage is the speed and ease in which the plate can be changed.

The evolution of the curved plate for rotary screens has paralleled the development of flat plates.

The early curved plates were made from yellow brass rolled copper, and rolled grade A phosphor bronze.

Both copper and phosphor bronze were chromium plated to lengthen their life. It was found that phosphor bronze plated better, and usually lasted longer than chrome-plated copper. Monel was tried and is used to some extent but its corrosion resistance was not usually good enough. Stainless steel is satisfactory from a corrosion resistance point of view, but often fails mechanically.

This led to the introduction of Inconel which is equal to stainless steel from a corrosion resistance point of view and is better mechanically. A large number of Inconel plates are in operation over a period of a number of years with only a comparatively few breakages.

Curved screen plates for paper machine screens can be classified in order of quality as follows: (1) Inconel; (2) stainless steel; (3) chrome-plated rolled phospher bronze; (4) chrome-plated hard-rolled copper; (5) unplated rolled phosphor bronze; (6) unplated hard-rolled copper; and (7) rolled yellow brass.

To obtain best results from screen plates a few suggestions are offered. They are precision products and should be handled as such. They should be carefully handled and stored to prevent damage to slots and to avoid scratching the surface of plated plates.

The plates should be carefully installed in the screens, particularly with Witham and similar type fasteners, being careful to clean out all pulp from the stationary bars and wipe off the locking bars so that when the plates are installed no foreign material will be wedged between the fasteners and the plates. The locking bars should be tightened down evenly.

Screen plates should be cleaned carefully with nonmetalic scrapers. If possible do not walk on screen plates—slots may thus be distorted by bending the bars. The plates should be examined for rivet failure, and any broken rivets be replaced. Broken frames should be welded or sent in for repairs without delay.

Received Sept. 7, 1950. Presented at the Fifth Engineering Conference sponsored by the Technical Association of the Pulp and Paper Industry, Cincinnati, Ohio, Oct. 2–5, 1950.

Determination of Iron in Wood and Wood Pulp

R. M. KINGSBURY

A rapid and precise method for the determination of iron in wood and in papermaking and dissolving pulps is described. The procedure consists of (1) wet digestion of the material, (2) reduction of iron to the ferrous form, and (3) spectrophotometric determination of iron in the form of the *o*-phenanthroline complex. Sensitivity and reproducibility are in the range of 1 p.p.m.

Work at the U. S. Forest Products Laboratory on the bleaching and purification of wood pulps has shown a need for a more rapid and reliable method for determining iron in wood and pulps than the present TAPPI Standard T 434 m (*10*). The method described in this report was developed to meet this need.

Several procedures for wet ashing organic material (*1, 3, 5, 7, 9*) and determining traces of iron with *o*-phenanthroline (*1, 2, 4, 8, 9*) are described in the literature. Certain features of these procedures have been selected and combined to provide a rapid and precise procedure for use on cellulosic materials.

The procedure, which includes wet ashing the sample, reducing the iron to the ferrous form and spectrophotometrically determining the reduced iron as the *o*-phenanthroline complex, avoids several disadvantages inherent in the present TAPPI method for acid-soluble iron in paper. These are: (1) incomplete removal of iron from the sample, (2) time-consuming separation of iron from the extraction solution and the attendant possibility of loss of iron, (3) instability of the ferric-thiocyanate complex, and (4) the necessity of preparing new standards for each sample analyzed. Further advantages of the present method are that other metallic impurities, such as copper, calcium, or manganese, can be determined on aliquots of the wet-ashed material by selecting a suitable size of sample and adjusting the amount of wet ashing acids, and that total iron is determined whereas only acid-soluble iron is determined by the TAPPI method.

DESCRIPTION OF METHOD

Special Apparatus

Apparatus for the determination of iron by the Forest Products Laboratory method, other than that generally available in paper mill laboratories, consists of:

R. M. Kingsbury, Chemist. Forest Products Laboratory, maintained at Madison, Wis., in cooperation with the University of Wisconsin. Forest Service U. S. Department of Agriculture.

1. Pyrex Kjeldahl flask, 1-liter capacity.
2. Glass water-jet pump and adapter tube (Fig. 1).
3. Spectrophotometer or filter photometer with monochromatic filter showing maximum transmission at 480 to 520 mmu, and absorption cells with a light path of 10 to 50 mm.

Reagents

The reagents required for the determination of iron by the Forest Products Laboratory method are:

1. Sulphuric acid, concentrated C.P., as nearly iron-free as possible.
2. Nitric acid, concentrated C.P., as nearly iron-free as possible.
3. Perchloric acid, 70 to 72% A.C.S. standard.
4. Hydroxylamine hydrochloride, 10 grams dissolved and diluted to 100 ml. in distilled water.
5. Hydrochloric acid, approximately 2 *N*.
6. *o*-phenanthroline, 0.5% in water. Solution can be effected by heating or with a small amount of alcohol.
7. Ammonium hydroxide, concentrated reagent diluted with an equal volume of water.
8. Methyl orange indicator solution.
9. Standard iron solution, 0.1 gram of iron per liter. Dissolve 0.7022 gram of pure ferrous ammonium sulphate, $FeSO_4 \cdot (NH_4)_2\ SO_4 \cdot 6H_2O$ and 0.2035 gram of pure ammonium persulphate, $(NH_4)_2 S_2O_8$, in water containing 1 ml. of concentrated H_2SO_4 and dilute to exactly 1 liter, or dissolve 0.1000 gram of electrolytic iron in 50 ml. of 1:3 HNO_3, boil to expel oxides of nitrogen, and dilute to 1 liter with distilled water. Dilute 10 ml. of the original solution to 100 ml. for the standard solution, which will then contain 0.00001 gram of iron per milliliter.

Test Sample

Select a representative sample of the material and cut or break it into pieces $^1/_2$ inch square or smaller. Wood samples should be ground to pass a 40-mesh screen. For convenience in weighing, the sample should be air-dry or brought to a low moisture content. Care should be used to avoid contamination of the sample by handling or exposure to dust in the atmosphere.

Procedure

All glassware must be rinsed with hot dilute hydrochloric acid and distilled water before using.

Wet Ashing. Weigh out an amount of air-dry or moist pulp equivalent to 5.0 grams of oven-dry material and place it in a Pyrex Kjeldahl flask. Add 30 ml. of concentrated nitric acid and 5 ml. of concentrated sulphuric acid and heat gently over a low gas flame until vigorous reaction and evolution of nitrous oxide fumes start. Remove the flask from the flame and place the flask on a stand with the adapter tube of the water-jet pump inserted in the mouth of the flask to draw away the fumes as shown by Fig. 1. As soon as the reaction subsides, add 5 ml. of perchloric acid and heat gently until the solution chars or darkens and begins to clear again, then heat strongly until dense white fumes appear near the bottom of the flask. If the solution does not clear after charring, add 0.5 ml. of perchloric acid and heat again until the white sulphur trioxide fumes

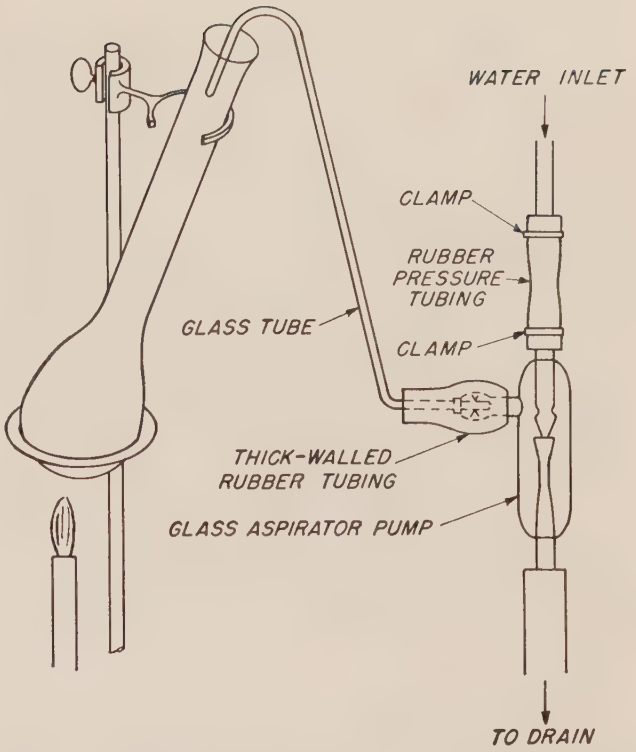

Fig. 1. Arrangement of digestion flask and pump for collection of acid fumes in the wet oxidation of wood or pulps

appear. Repeat this treatment until a water white or pale yellow solution is obtained, then continue heating an additional 5 or 10 minutes. Cool the solution to room temperature and transfer to a 50-ml. volumetric flask. Rinse the digestion flask once with about 10 ml. of hot 2 *N* hydrochloric acid, then several times with small amounts of distilled water, adding the rinsings to the solution in the volumetric flask. Cool the solution, dilute to 50 ml., and mix thoroughly.

Reduction of Iron to the Ferrous Form. Pipet 10 ml. of the solution into a 50-ml. volumetric flask which has been rinsed with hot dilute hydrochloric acid. Add 2 ml. of 10% hydroxilamine hydrochloride solution, mix thoroughly, and after 2 or 3 minutes dilute to 50 ml. with distilled water.

Formation of the o-Phenanthroline Complex and Transmittancy Measurement. Pipet 10 ml. of the reduced solution into a small Erlenmeyer flask with a clean dry pipet. Add 3 drops of methyl orange indicator solution and titrate with ammonium hydroxide (1:1 solution) until the color just deviates from pink. Calculate the amount of the ammonium hydroxide solution required for the remaining 40 ml. of solution. Add 1 ml. of 0.5% *o*-phenanthroline, mix well, then add the calculated amount of ammonium hydroxide while continuously whirling the flask. Cool and dilute to 50 ml. Measure the light transmission through 20 mm. of the solution, using a light filter with maximum transmission between 490 and 515 mmu and distilled water as the standard for 100% transmission. The amount of iron in the pulp is then obtained from a calibration curve prepared as described below.

Calibration with Standard Iron Solutions. Evaporate a mixture containing 30 ml. of concentrated nitric acid, 5 ml. of concentrated sulphuric acid, and 5 ml. of perchloric acid to fumes of sulphur trioxide in a Kjeldahl

flask and transfer to a 50-ml. flask, rinsing with hot 2 *N* hydrochloric acid and distilled water as described for the digestion of pulp or wood samples. Cool and dilute to 50 ml. Divide the solution into five equal portions by pipetting 10 ml. into each of four additional 50-ml. flasks, using a clean dry pipet. Prepare a series of solutions by carefully measuring 0, 2, 4, 6, and 8 ml. of the dilute standard iron solution into the separate flasks, then add 2 ml. of 10% hydroxylamine solution to each of the solutions, mix and dilute each to 50 ml. Develop the *o*-phenanthroline-iron complex and measure the light transmission of each of the solutions exactly as described for pulp or wood samples. Plot the transmittancies as abscissa and the amounts of iron in parts per million as ordinates on semilogarithmic paper, the values for ordinates being 0, 20, 40, 60, and 80 parts of iron per million parts of oven-dry sample. Since the standard solutions contain the same amounts of reagents that are used in analysis of pulp samples, no blank correction is necessary. To obtain reliable results, the calibration curve should be prepared from data obtained with the particular photometer used for analysis.

RESULTS AND DISCUSSION

The wet-ashing procedure described in this method is a convenient, rapid, and positive way to bring all iron into solution for analysis. Digestion of a 5-gram sample of pulp or wood is usually complete in about 30 minutes and seldom requires more than 5 ml. of perchloric acid.

Certain precautions are necessary in handling the perchloric acid solution (*6*) and in digesting the sample. The preliminary oxidation with nitric and sulphuric acids is essential to avoid danger of fire or explosion when the perchloric acid is added. However, the perchloric acid can be added without danger as soon as the vigorous evolution of nitrous oxide subsides. Further heating at this stage without perchloric acid makes the digestion difficult, and may increase the amount of perchloric acid required to complete the oxidation. It is also advisable to conduct the digestion under a hood, since some of the acid fumes may not be collected by the water-jet pump. Use of the pump as indicated in Fig. 1, however, prevents condensation of acid fumes in the hood and flues.

Although the reason is not apparent, the rinse with hot dilute hydrochloric acid followed by several rinses with distilled water is necessary to transfer all of the iron from the digestion flask. Instances have been observed when as much as 20% of the iron present remained in the digestion flask when the hydrochloric acid rinse was omitted.

No comments concerning details of the reduction of iron to the ferrous form or development of the ferrous iron-*o*-phenanthroline complex are necessary here since these steps are covered adequately in the literature.

Elements other than iron apparently are not present in wood or pulps in sufficient quantities to cause appreciable interference in the development of the colored complex. Calcium sulphate or silica may precipitate in some instances, but these settle readily or can be removed by filtering the acid solution through acid-washed filter paper.

Transmittancy data for standard iron solutions prepared according to the prescribed procedure are given in Table I. A plot of these data on semilogarithmic graph paper forms a straight line and shows that the light absorption by the colored complex is sufficient to provide a sensitivity of 1 p.p.m. when an aliquot equivalent to 1 gram of sample is used. Digestion of a larger sample, 5 grams, is specified to avoid inconsistent results due to nonuniform distribution of iron in the sample. The stability of the *o*-phenanthroline-iron complex is also illustrated by these data.

Table I. Transmittancy Data for Standard Iron Solutions

Volume of dilute iron solution used, ml.	*Weight of iron, mg.*	*Equivalent concentration in pulp samples,[a] p.p.m.*	*Transmittancy[b]*		
			Immediate, %	*After 3 days, %*	*After 10 days, %*
0	0.0	0	93.5	94.5	94.2
2	0.02	20	72.3	72.5	71.2
4	0.04	40	56.3	56.3	56.1
6	0.06	60	43.0	43.2	42.5
8	0.08	80	34.0	34.0	33.7

[a] Sample weight 1 gram or an aliquot equivalent to 1 gram.
[b] Compared to distilled water, using a 20-mm. cell and a filter showing maximum transmission at 490 mmu.

Table II. Recovery of Iron Added to Commercial Alpha Pulps

Pulp	*Iron added, p.p.m.*	*Total iron found, p.p.m.*	*Iron recovered, p.p.m.*
A	0	15.0	...
A	0	13.5	...
A	5	19.4	5.2
A	10	23.0	8.8
A	15	30.0	15.8
B	0	15.0	...
B	0	14.0	...
B	0	15.0	...
B	0	15.0	...
B	3	18.0	3.0
B	3	17.0	2.0
B	6	22.0	7.0
B	6	21.0	6.0
B	15	30.0	15.0
B	15	30.0	15.0

The accuracy of the method is illustrated by data given in Table II showing the iron content of two commercial pulps and the recovery of added iron.

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Received Feb. 8, 1951. Presented at the annual meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 19–22, 1951.

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

A. Joseph Barth, Consulting Engineer, Sumner S. Sollitt Construction Co., Chicago, Ill., a 1940 graduate of Chicago Tech.

Joseph E. Bradley, Jr., Research Chemist and Sales Representative, Watson-Park Co., Ballard Vale, Mass., a 1949 graduate of Bowdoin College.

George L. Burgon, Hardboard Superintendent, Canadian Forest Products Ltd., Pacific Veneer and Plywood Div., New Westminster, B. C., Canada, a 1931 graduate of Fort William Collegiate Institute.

Gerald L. Burke, Student, New York State College of Forestry, Syracuse, N. Y.

Ray M. Campbell, Jr., Product Specialist, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1941 graduate of Bucknell University.

John E. Cash, Erection Engineer, Beloit Iron Works, Beloit, Wis., a 1949 graduate of the University of Manitoba.

Robert T. Cassady, Vice-President, The Jackson Box Co., Norwood, Ohio. Attended Notre Dame University.

Blake B. Coldwell, Chemist, Canada Department of Justice, Ottawa, Ont., Canada, a 1942 graduate of McGill University with a Ph.D. degree in 1951.

Ralph M. Cook, Jr., Chemist, Calco Chemical Div., American Cyanamid Co., Bound Brook, N. J., a 1950 graduate of the University of Maine.

Eldon Cronquist, Plant Engineer, Ashtabula Corrugated Box Co., Ashtabula, Ohio, a 1932 graduate of the University of Illinois.

I. James Cummings, Development Engineer, The Dow Chemical Co., Midland, Mich., a 1948 graduate of Purdue University.

Leslie A. Dow, Supervisor, Eastern Corp., Brewer, Me., a 1942 graduate of the University of Maine.

James P. Dwyre, Student, New York State College of Forestry, Syracuse, N. Y.

David N. Finnie, Director, Trist Colloidal Products Patented, New York, N. Y., a graduate of McGill University.

Joseph F. Gill, Assistant to the General Manager, Ryegate Paper Co., E. Ryegate, Vt.

Arnold L. Ginsberg, Technical Director, National Container Corp., Long Island City, N. Y., a 1950 graduate of Cornell University.

Parker W. Gray, Graduate Student, University of Michigan, Ann Arbor, Mich., a 1950 graduate of the University of Maine.

William C. Hasselo, Plant Manager, Container Corp. of America, Cleveland, Ohio. Attended Wilcox and Fenn Colleges.

Ernest R. Hess, Jr., Chemical Engineer, Gary Paper Mills, Inc., Gary, Ind., a 1950 graduate of the University of Maine.

John E. Johnson, Engineer, Billeruds AB, Saffle, Sweden, a graduate of Malmo Technical College.

Sirkka Juusela, Mill Chemist, Lohja-Kotka O/Y, Lohja, Finland, a 1943 graduate of Finland Institute of Technology.

Shigeyoshi Kitsukawa, Planning and Research, Honshu Paper Mfg. Co. Ltd., Chuo-ku, Tokyo, Japan, a 1948 graduate of Tokyo University.

Otto Lazar, Librarian, Technical University, Vienna, Austria.

Norman M. LeMaistre, Chief Chemist, Gulf States Paper Corp., Tuscaloosa, Ala., a 1951 graduate of the University of Alabama.

Charles G. Lester, Jr., Assistant Research Chemist, General Cable Corp., Bayonne, N. J., a 1943 graduate of Pratt Institute.

Tom E. Loessi, Production Chemist, Latex Fiber Industries, Inc., Beaver Falls, N. Y., a 1930 graduate of Ohio University.

Tadashi Nagano, Staff Member, Tokyo University, Tokyo, Japan, a 1950 graduate of Tokyo University.

Novart Matossian, Librarian, Colgate-Palmolive-Peet Co., Jersey City, N. J., a 1921 graduate of Smith College.

John D. McAleer, Salesman, Burgess Pigment Co., Paterson, N. J.

David W. McLean, Research Chemist, Howard Smith Paper Mills, Cornwall, Ont., Canada, a 1950 graduate of the University of Toronto.

Misao Murai, Technical Director, Daishowa Paper Mfg. Co. Ltd., Fuji-gun, Shizuoka Pref., Japan, a 1919 graduate of Kyushu Imperial University.

John P. Nauta, Mechanical Engineer, Balatum (N.V.), Huizen (N.H.), The Netherlands, a 1946 graduate of the Technical University, Delft.

Paul Podolier, Research and Development Engineer, Bowaters Fibre Containers Ltd., Croydon, Surrey, England, a graduate of the University of Berlin, Germany.

Elvin G. Powell, Chief Chemist, National Biscuit Co. Carton Factory, Marseilles, Ill., a 1949 graduate of Iowa State College.

Richard W. Reiter, Chemist, National Starch Products, Inc., New York, N. Y., a 1947 graduate of Wheaton College.

Clifford S. Reppe, Sales Manager, Hercules Powder Co. (Canada) Ltd., Freeman, Ont., Canada. Attended Multnomah College.

Marguerite Ritchie, Librarian, Engineering Library, University of Maryland, College Park, Md., a 1939 graduate of the University of Maryland.

Donald Rushmore, Chemist, J. &. J. Rogers Co., Au Sable Forks, N. Y. Attended Antioch College.

Charles J. Seiler, Chemist, Bakelite Corp., Div. of Union Carbide & Carbon Corp., Bloomfield, N. J., a 1942 graduate of Brooklyn College, with an M.S. degree from the Polytechnic Institute in 1947.

Gorham G. Simmons, Technical Assistant to the Manager, Berwin Paper Mfg. Corp., Dansville, N. Y., a 1948 graduate of Northeastern University.

Joseph F. Steinbruner, Plant Manager, International Printing Ink Co., Chicago, Ill.

John E. Stone, Assistant Research Officer, National Research Council of Canada, Saskatoon, Sask., Canada, a 1948 graduate of the University of London with a Ph.D. degree.

Peter Suttie, Maintenance and Construction Engineer, Quebec North Shore Paper Co., Baie Comeau, P. Q., Canada, a 1933 graduate of Heriot-Watt College.

Isami Tachi, Professor, Kyoto University, Kyoto, Japan, a 1924 graduate of Tokyo University with a Doctor of Agriculture degree.

Roman F. Weber, General Supervisor, International Harvester Co., Chicago, Ill.

Leo B. Wickstrom, News Mill Superintendent, Industries Klabin do Parana de Celulose, Sao Paulo, Brazil, a 1938 graduate of the Technical University of Finland.

Marshall A. Wright, Jr., New England Technical Sales and

Service, Rohm & Haas Co., Philadelphia, Pa., a 1940 graduate of the Massachusetts Institute of Technology.

Max L. Woehle, Chemical Engineer, Container Corp. of America, Fernandina, Fla., a 1948 graduate of the University of Florida.

TAPPI Notes

John H. Ainsworth, formerly of the Sangamon Paper Mills, is now Assistant Chief Engineer, Allied Paper Mills, Kalamazoo, Mich.

Kenneth A. Arnold, Chief of Container Research, St. Regis Paper Co., has been transferred from Oswego, N. Y., to Deferiet, N. Y.

Robert J. Becker, on leave form the Riegel Paper Corp., is now a Lieutenant at the Engineering Training Center, Fort Belvoir, Va.

Stuart I. Bergman, formerly of the Institute of Paper Chemistry, is now in the Research and Development Department, Brown Co., Berlin, N. H.

Charles A. Bicking, formerly of the Hercules Powder Co., is in the Ordnance Research and Development Div., Office of the Chief of Ordnance, Washington, D. C.

Oscar K. Chapman is now Shift Superintendent, Kraft Pulp Div., Weyerhaeuser Timber Co., Longview, Wash.

Miss R. M. Karapetoff Cobb has resigned, due to illness, as Research Director for the Lowe Paper Co., Ridgefield, N. J. Miss Cobb will continue to serve as Technical Adviser to the Lowe Paper Co. and is located at 105 Grovers Ave., Winthrop, Mass.

Alex Coutras, formerly Student, New York State College of Forestry, is now a Plastics Chemist for the American Cyanamid Co., Stamford, Conn.

Eugene De Luca, formerly of G. D. Jenssen Co., Inc., is now with Irving Pulp & Paper Co., Fairville, New Brunswick.

G. Robert Donelson, formerly with the Brightwater Paper Co., is now Chemist for the Claremont Paper Co., Claremont, N. H.

Eugene D. Frost of the Gaylord Container Co., Bogalusa, La., is on a leave of absence and is with Battery D, 71st AFA Bn., Fifth Armored Division, Camp Chaffee, Ark.

John B. Gough, formerly Chief Engineer for the Mead Corp., Chillicothe, Ohio, is now Consulting Engineer for Mead.

Julius Grant, formerly of Thomas Owen & Co., Ltd., is now Director of New Bury Paper Mills, Ltd., Gigg, Bury, Lancashire, England.

K. Torsten Hasselstrom is now Chief of the Organic Laboratory Unit, Research & Development Laboratories, U. S. Quartermaster Depot, Philadelphia, Pa.

Richard Hazen, formerly with Malcolm Pirnie Engineers, is now a Consulting Engineer, 110 E. 42nd St., New York 17, N. Y.

John H. Heuer, formerly General Manager of APW Products, Inc., is now Superintendent of the Bureau of Tests, Great Northern Paper Co., Millinocket, Me. Mr. Heuer was formerly Technical Director for the Newton Falls Paper Co. and the St. Regis Paper Co. and is Chairman of the TAPPI Coating Committee.

Harry F. Highfield, formerly of the Continental Paper Co., is now Superintendent and Chemical Engineer for the Sangamon Paper Mills, Inc., Eaton, Ind.

D. A. Huber, Owner of the Huber Feltex Co., has transferred his office from Atlanta, Ga., to Toccoa, Ga.

Helen U. Kiely, Chief Chemist for the American Writing Paper Co., Holyoke, Mass., sailed to Europe on July 3 for a tour. A hearty farewell party was given her in New York by friends in the industry prior to her departure.

Anthony Le Sauteur, formerly Student at St. Michael's College, is now Chemist for the Canadian International Paper Co., Trois Rivieres, P. Q.

Elisha B. Lewis, formerly of the Southern Chemical Cotton Co., is now Research Chemist at the Institute of Industrial Research, University of Chattanooga, Chattanooga, Tenn.

William F. Lewellyn of the Marathon Corp. has been transferred from Menominee, Mich., to Oswego, N. Y.

James H. McClure is now Plant Manager, Sherman Paper Products Corp., Chicago, Ill.

Frank Makara, Patent Attorney, is now located at 65 Beaumont Circle, Tuckahoe, N. Y.

Richard J. Murtaugh, formerly of the American Cyanamid Co., is now with the St. Regis Paper Co., Deferiet, N. Y.

Hugh T. Nicholson, formerly of the District of Columbia Paper Mills, is now Superintendent for the National Vulcanized Fibre Co., Yorklyn, Del.

Frederick Olsen, Technical Director of Olin Industries, Alton, Ill., recently received an honorary degree of Doctor of Engineering from Washington University, St. Louis, Mo.

Henry Ostrowski, formerly with the Brown Corp., is now Chief Chemist for the Hinde & Dauch Paper Co., Ltd., Trenton, Ont.

Robert S. Painter, formerly of the New York and Pennsylvania Co., is now a graduate student at Bucknell University, Lewisburg, Pa.

E. W. Petrich, formerly of the University of Cincinnati, has joined the Technical Department of the Howard Paper Mills, Dayton, Ohio.

George H. Pringle is now Chief Engineer of the Mead Corp., Chillicothe, Ohio.

Hugh P. Quinn, formerly of the Bagley & Sewall Co., is now Service Manager for the Midwest-Fulton Machine Co., Dayton, Ohio.

Thomas M. Riddick is the author of an article in the July issue of *Harper's* Magazine, entitled "Dowsing is Nonsense." This article presents an engineer's views of the speculative information presented by Kenneth Roberts in his book "Henry Gross and His Dowsing Rod." Mr. Riddick's contribution, by the way, really tells the layman where the water is and how to get it.

John E. Schermerhorn, formerly Student, New York State College of Forestry, is now Control Chemist for the Champion Paper & Fibre Co., Pasadena, Tex.

James R. Schoettler, formerly Student, Institute of Paper Chemistry, is now Research Chemist for Kimberly-Clark Corp., Neenah, Wis.

David C. Scott, Jr., is now President of Scott Testers, Inc., Providence, R. I.

John E. Spalding, Process Engineer of the Marathon Corp., has been transferred from Menasha, Wis., to Oswego, N. Y.

Andrew G. Stewart, formerly of Bertrams, Ltd., is now Board Mill Superintendent for the Tasmanian Board Mills, Ltd., Launceston, Tasmania.

Eric H. Sundback, formerly Student, New York State College of Forestry, is now a trainee at Dixie Cup Co., Easton, Pa.

Bernard J. Twisdale, formerly of the St. Lawrence Paper Corp., is now Assistant Superintendent, National Paper Corp., Ransom, Pa.

Wyman F. Uhl, formerly Student at Western Michigan College, is now Chemist for American Coating Mills, Elkhart, Ind.

Herman W. Verseput, formerly Student, Institute of Paper Chemistry, is now in the Research Department of Robert Gair Co., Inc., Uncasville, Conn.

E. N. Wennberg, formerly of the Columbia River Paper Mills, is now Superintendent of Paperboard Products, Weyerhaeuser Timber Co., Longview, Wash.

Rolf G. Westad, President of the Borregaard Co., Inc., has moved his office to Norway House, 290 Madison Ave., New York 17, N. Y.

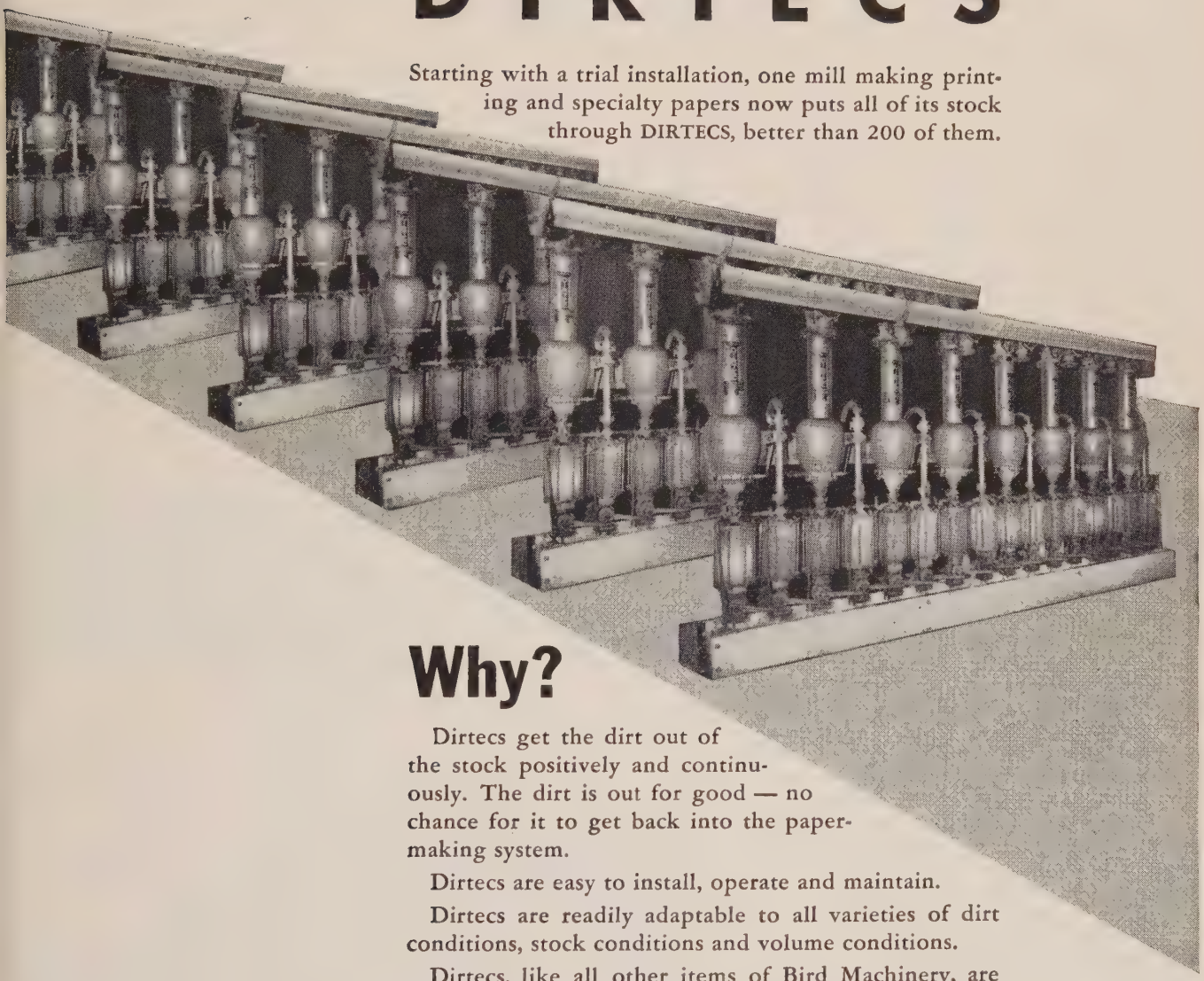
James H. Wing is now Research Physicist for the Hollingsworth & Whitney Co., Waterville, Me.

* * *

B. B. Bhalla has succeeded K. P. Sagreiya as official corpo-

.....and now they have more than 200 DIRTECS

Starting with a trial installation, one mill making printing and specialty papers now puts all of its stock through DIRTECS, better than 200 of them.



Why?

Dirtecs get the dirt out of the stock positively and continuously. The dirt is out for good — no chance for it to get back into the papermaking system.

Dirtecs are easy to install, operate and maintain.

Dirtecs are readily adaptable to all varieties of dirt conditions, stock conditions and volume conditions.

Dirtecs, like all other items of Bird Machinery, are built to help you make *better paper and more of it per day at lower cost per ton.*

BIRD MACHINE COMPANY

SOUTH WALPOLE • MASSACHUSETTS

rate representative of the Ballapur Paper & Strawboard Mills Ltd., Balharshah, G. I. P. Rly, State of Madhya Padesh, India.

Industry Notes

NPA Order M-69 restricts users of sulphur to 100% of their average monthly consumption for 1950, with seasonal adjustments. Mills using more than 20 tons of sulphur are required to file reports with the NPA by the 28th of each month, giving data on the previous month's consumption, inventories at the end of the previous month, estimated consumption of the current month, and estimated inventories at the end of the current month. Form NPA F 98 is to be used.

* * *

Press reports indicate that a four million dollar groundwood mill is to be built at Yates, Alberta.

* * *

The telephone number of the APPA Washington office has been changed to Metropolitan 2503-4.

* * *

The record-keeping required of manufacturers and others operating under the controlled materials plan is set forth in a booklet "Allotment Accounting for Consumers Under CMP" has been issued by the National Production Authority, U. S. Department of Commerce, Washington 25, D. C., which may be obtained upon request. The manual explains what records must be established and maintained to account for allotments of steel, copper, and aluminum. It does not specify any particular forms to be used, leaving this to individual businessmen, but does emphasize the requirement that records of controlled materials allotments be accurate in all respects.

* * *

The Office of Price Stabilization has announced the following ceilings on twelve standard grades of wood pulp produced in the United States and four grades of imported wood pulp comprising the bulk of shipments from overseas. Ceilings will not be fixed on imports from Canada but the Canadian Department of Defense Production has assured the United States Government that no general price increase will be authorized without prior consultation with the United States.

For domestic wood pulp the prices are at levels representing pre-Korea prices plus amounts deemed adequate to cover cost increases since June, 1950. Rollbacks on a substantial portion of market pulp are expected. The ceilings on overseas pulp represent the lowest levels of prices during the second quarter of 1951.

Following are ceilings for domestic standard grades per short air-dry ton, delivered to the consumer's mill.

Bleached sulphite	$140.00	Sulphite screenings	72.50
Unbleached sulphite	132.50	Sulphate screenings	67.50
Bleached sulphate	145.00	Groundwood screenings	60.00
Semibleached sulphate	140.00	Unbleached sulphate side-runs	132.50
Unbleached sulphate	132.50	Standard newsprint side-runs	92.50
Bleached soda	140.00		
Groundwood	92.50		

Manufacturers must absorb freight charges up to certain specified amounts.

Delivery costs above these amounts may be added to the ceiling prices. Following are the maximum freight charges per short air-dry ton the manufacturer must absorb:

Production Area	*Below 50%*	*50–80%*	*About 80%*
Northeast	$16.00	$14.00	$11.00
Lake Central	16.00	14.00	11.00
Southern	20.00	18.00	15.00
West Coast	23.50	21.50	18.50

Following are the ceiling prices on standard grades of imported wood pulp per short air-dry ton on dock, Atlantic Seaboard:

Unbleached sulphite	$200.00
Unbleached sulphate	200.00
Bleached sulphite	225.00
Bleached sulphate	230.00

The United States produces about 40% and consumes about 50% of the world's wood pulp. It purchases about one third of the wood pulp moving in international trade. About 10% of the U. S. domestic production is market pulp made for sale.

About 260 U. S. mills produced 14,800,000 tons of pulp in 1950. The same year the paper industry purchased 2,900,000 tons of wood pulp, of which 900,000 tons were domestic, 1,300,000 tons Canadian, and 700,000 tons overseas, chiefly from Sweden and Finland, of which the rayon and other chemical converting industries purchased about 680,000 tons of special grades of sulphite pulp, about 440,000 tons from U. S. mills and 240,000 tons from Canada.

* * *

John Maloney of Hoberg Paper mills is now Director of the Pulp, Paper, and Board Division of NPA and John Franzen of Hammermill Paper Co. is Deputy Director. G. J. Ticoulet has been advanced to the position of Deputy Assistant Director of the Chemical, Rubber, and Forest Products Bureau of NPA.

* * *

Das Paper (February, 1951) reports that before the war the German paper industry had a yearly production capacity of 2,700,000 metric tons of paper and 1,000,000 metric tons of paperboard, and was third in world production, the United States and Canada being first and second, respectively. Its yearly per capita consumption of 45–50 kilos was surpassed by the United States and Great Britain. Total sales of the Western German paper industry were increasing at about 25,000,000 yearly.

Of the total paper and board capacity, 15% was situated on the east side of the Oder and Dniester Rivers, and a further 45% in the Russian zone. Since both provinces have been cut off only the remaining 40% is located in the Federal Republic.

With direct reference to paper grades, about two thirds of the newsprint production has been lost. Of the former wood pulp capacity, about 35% is now in Polish occupied territory and 25% in the Soviet zone. All the other large sulphite pulp mills are located beyond the Oder and Dniester rivers. Of the remaining 40% in the Federal Republic all are sulphite wood pulp mills.

On the basis of these data, Germany lost 2,445,000 short tons of paper and board capacity, and 1,629,000 short tons of wood pulp capacity which includes all of Germany's sulphate pulp capacity, 59,000 tons (Basis—Germany's 1938 production of pulp and paper). The per capita consumption in Western Germany in 1949 was 57 pounds. In 1950 it increased to 71 pounds.

* * *

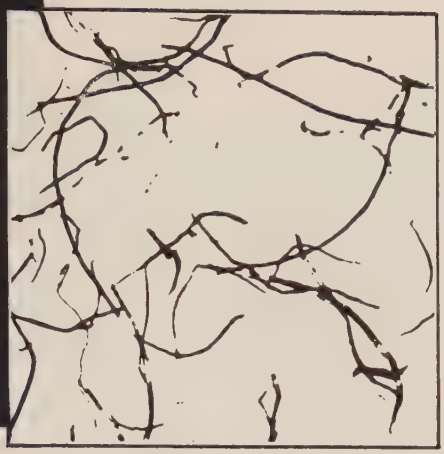
The National Production Authority, U. S. Department of Commerce, Washington 25, D. C., has issued a booklet "Questions and Answers on the Controlled Materials Plan." This is available on request and gives answers to the questions most frequently asked concerning CMP.

* * *

During the third quarter the pulp and paper mills in Sweden will have to pay the following business cycle equalization charges for pulp and paper exported:

Chemical pulp for paper	$90.71 per air-dry metric ton
Dissolving pulp	86.85 per air-dry metric ton
Mechanical pulp	23.16 per air-dry metric ton

LOOK WHAT CURLATION CAN DO FOR *YOUR* PULP!

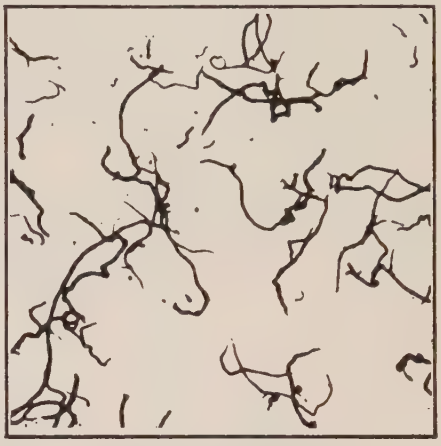


Uncurlated Bleached Southern Kraft

Curlated Bleached Southern Kraft

Photomicrographs of curlated and uncurlated pulp, showing how much curlation bends and twists fibers . . . changes fiber shape and diameter . . . yet, does not affect freeness. Any fiber bundles and dirt with the fibers are reduced by Curlator's patented rubbing and rolling process. *Note* in uncurlated photomicrographs how straight and coarse the fibers are . . . then see how curlation curls and thins fibers. That's why curlation makes a softer, more flexible, springier, smoother sheet.

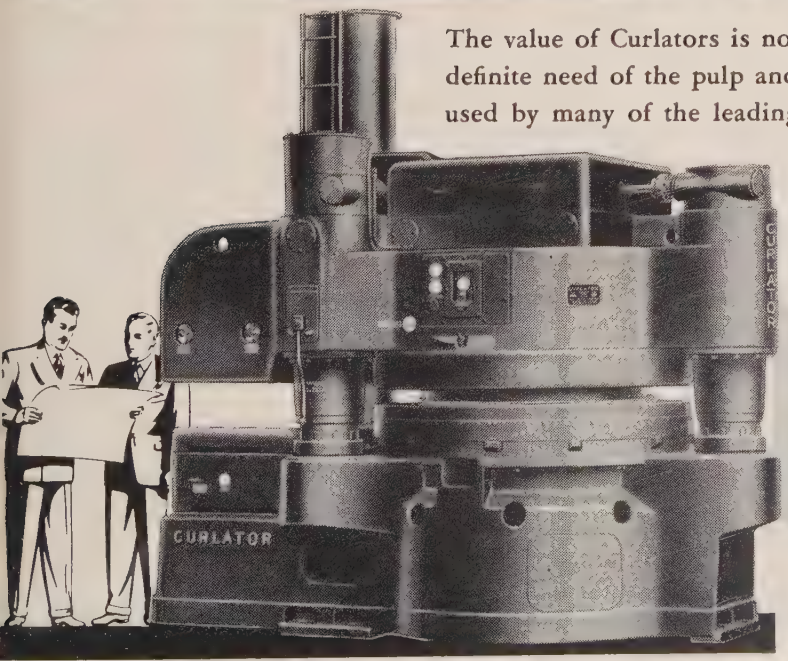
Uncurlated Bleached Sulphite



Curlated Bleached Sulphite

ONLY CURLATED PULP Gives You ALL These PLUS Qualities in Paper

√ Softer! √ Smoother!
√ Stronger! √ Cleaner!
√ More Flexible!



The value of Curlators is now a matter of record. Developed to fill a definite need of the pulp and paper manufacturers, Curlators are now used by many of the leading paper companies. They are thoroughly engineered and precision built to give long and satisfactory service.

WRITE *today for more detailed information.*

CURLATOR†
Corporation
565 BLOSSOM ROAD • ROCHESTER 10, NEW YORK

†T. M. Reg.—Curlator Corporation, Rochester, N. Y.

The total population of the United States, including the armed forces overseas on May 1, 1951 was 153,900,000. This figure represents an increase of 2,768,000 (1.8%) over the corresponding estimate for April, 1950.

* * *

About 10% of packaging printing is now done by the gravure process. Letterpress still accounts for 75% of the printing of all packaging materials. Aniline printing accounts for 10% and is increasing. This process is essentially letterpress, although the use of alcohol-type solvents and rubber plates have set this process apart. Most glassine, foil, and cellophane wraps are printed with aniline inks on rather simple presses on continuous rolls. Heat is often applied after printing to set the ink in the surface. Offset lithography accounts for only 5% of packaging printing but, is on the increase. This is because of the minimum amount of make-ready, the low cost of the plates and plate preparation, the flexibility of the process which allows corrections to color and test in a short time, and the versatility in relation to the surfaces printed.

* * *

The contract ceiling prices for logs per cord in the State of Maine have been set by the Office of Price Stabilization as follows:

	F.O.B. car	*Lake or stream*	*Roadside*	*Truck to mill (20 miles)*
Spruce and Fir				
Peeled	$17.00	$16.25	$14.00	$17.25
Rough	13.00	12.25	9.50	13.25
Hemlock				
Peeled	17.00	16.25	14.00	17.25
Rough	13.00	...	9.50	13.25
Poplar				
Peeled	16.00	15.25	13.00	16.25
Rough	12.50	...	9.00	12.75
Northern Hardwood				
Peeled	18.25	...	14.75	18.50
Rough	14.00	...	10.00	14.25
Pines				
Peeled	16.00	15.25	13.00	16.25
Rough	12.50	...	9.00	12.75

The prices established in New Hampshire and Vermont average from one to two dollars higher.

* * *

Chemical Week reports that the Houston Oil Co. will make paper in Texas if DPA grants a certificate of necessity. The company owns large tracts of timberland throughout Eastern Texas. If the plans go through Scott Paper Co. will be the joint contractor and owner of the 30 million dollar mill.

* * *

Edward G. Locke, Chief of the Forest Utilization Service in the Pacific Northwest Forest and Range Experiment Station, has been transferred from Portland, Ore., to Madison, Wis., where he is Chief of the Derived Products Section, Forest Products Laboratory.

* * *

The 23rd Exposition of Chemical Industries will be held at the Grand Central Palace, New York City from November 26 to December 1.

* * *

A Mrs. M. L. Waggoner of Winnsboro, Tex., with the damnedest luck imaginable, developed a very definite allergy to dishwater. Her doctor confirmed it. So her husband had to take over the daily chore of washing dishes. But immediately man's unfailing ingenuity came to the fore. Mr. Waggoner has started buying paper plates and dishes in two-dozen lots.

The Armstrong Forest Co., Johnsonburg, Pa., indicates that peeled pulpwood can now be a year-round tree farm crop. During the sap-peeling season a 6-inch band of bark is removed from around each tree without cutting into the wood. The girdle is then painted with a solution of sodium arsenite. In from 3 to 7 months bark loosens and begins to fall off. One gallon of sodium arsenite solution will treat 300–500 trees at a cost of less than 5 cents per cord. Bark loosens on pines, oaks, and aspen by late fall and on cherry, basswood, elm, poplar, birch, and maple by the end of winter.

* * *

On June 23 the Clemons Tree Farm at Montesano, Wash., celebrated its tenth anniversary. This farm, which is owned by the Weyerhaeuser Timber Co., was the first tree farm in the United States, dedicated to the perpetual production of trees. The idea spread to other regions and is now a national movement. Today in 29-tree farm states there are 3077 tree farms covering an area of 23,330,236 acres. Mississippi with 302 farms leads in number of farms with 887,224 acres. Texas with 273 farms has the largest area, 3,064,388 acres.

* * *

A large mechanically cleaned settling basin, one of the final projects of an extensive three-year program to improve the recovery processes and pollution abatement facilities at the Williamsburg, Blair Co., plant of West Virginia Pulp and Paper Co., was recently placed in operation.

Designed to clarify more than six million gallons of waste water daily and reduce to a minimum the flow of plant wastes into the Frankstown branch of the Juniata River, the basin was planned and built in compliance with orders of the Board. The installation cost was in the neighborhood of $175,000.

In the new system for handling mill wastes, effluents from the mill first pass through a screen which removes larger objects, such as wood chips. The wastes then are pumped through a pipe line to the basin, where filler, wood fibers, boiler house fly ash, and other sediment too fine to be removed in the plant processes, are settled out. After it is cleared in the retaining basin the water is returned to the stream through a pipeline. Sludge, which settles to the bottom of the basin, is collected and disposed of by a series of mechanical devices.

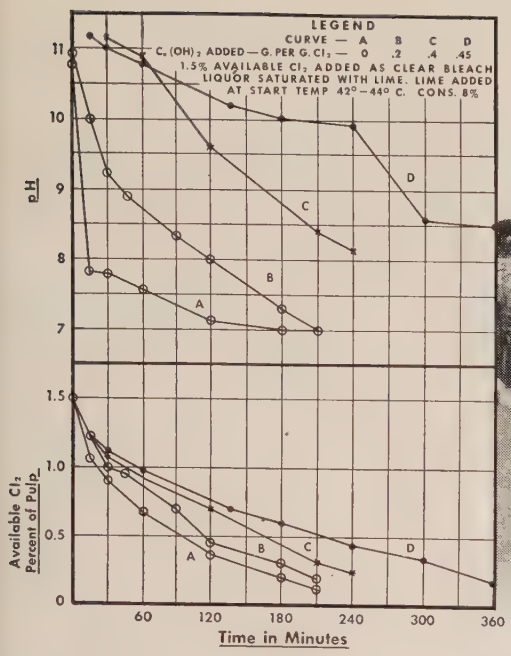
Engineers estimate that under normal conditions the new addition will remove each day approximately 15 tons of sludge from mill wastes and clarify approximately 3,500,000 gallons of water for return to the river. A 30-inch pipe line, 150 feet long, returns the water to the stream.

The settling basin is an improved version of a basin that has been operating successfully for more than a year at the company's plant at Tyrone.

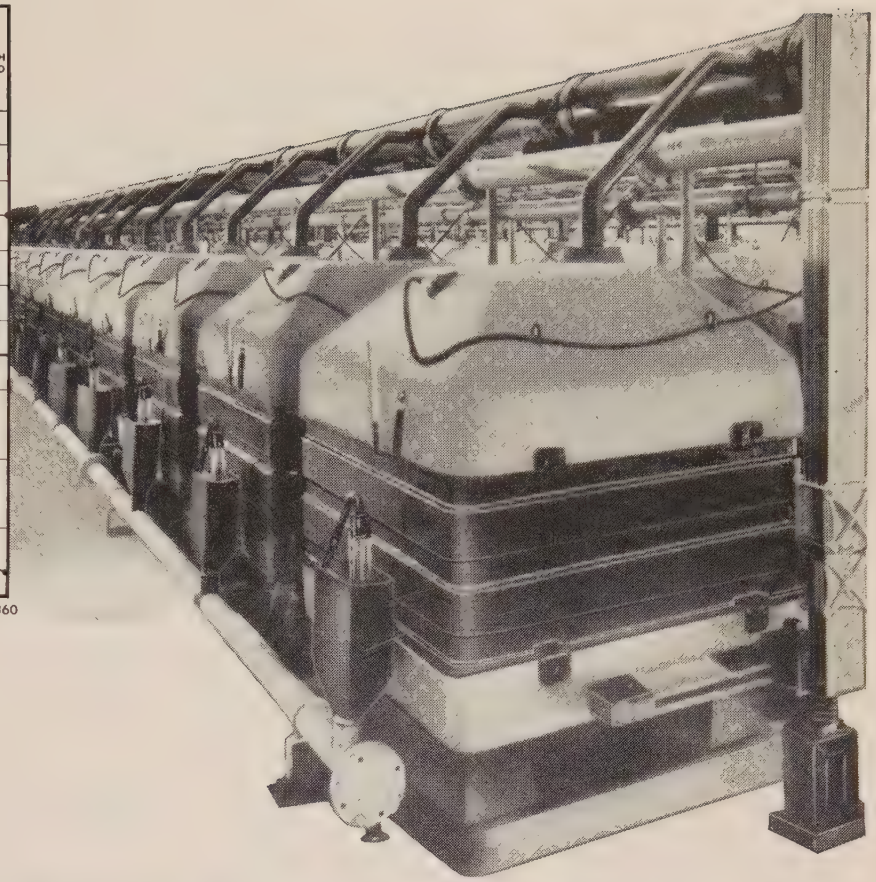
The Williamsburg basin, located on the west bank of the Frankstown branch, is a steel-reinforced concrete installation, 108 × 70 feet and 11 feet deep. In addition to the retention basin, which can hold about 500,000 gallons of waste water, the installation consists of sediment collection equipment, sludge storage tanks, and a pumping station which disposes of the collected solids.

After objects three eighths of an inch and larger have been removed by a new mechanical traveling screen, mill wastes enter the settling basin through 600 feet of 16-inch steel pipe extending from the present plant sewage system. These wastes are moved by two new pumps, each capable of handling 3500 gallons of water per minute. Each pump is capable of handling the entire flow from the mill. One is used as a standby.

The sediment begins settling out of the waste water as soon as it enters the basin. Four drag conveyors scrape constantly along the bottom of the basin and move the sludge into troughs which extend the full width of the basin at the lower end. Scraper type buckets collect the sludge in the troughs and elevate it to discharge hoppers located above the settling


LEGEND
CURVE — A B C D
$Ca(OH)_2$ ADDED — G. PER G. Cl_2 — 0 .2 .4 .45
1.5% AVAILABLE Cl_2 ADDED AS CLEAR BLEACH LIQUOR SATURATED WITH LIME. LIME ADDED AT START TEMP 42°–44° C. CONS. 8%
pH
Available Cl_2 Percent of Pulp
Time in Minutes
60 120 180 240 300 360

Effect of lime additions on pH and rate of chlorine consumption in a hypochlorite reaction with chlorinated sulfate pulp.



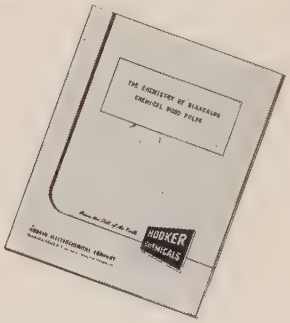
Starting Point for Better Paper

The important bleaching step, at many mills, is handled with high-purity chlorine produced in Hooker "S" Cells at Niagara Falls and Tacoma.

So efficient are the "S" cells, that their widespread use by licensees and by Hooker is responsible for nearly one-half of the chlorine produced in the United States.

When you use Hooker Chlorine you can be sure of uniformity that keeps your bleaching methods constant. What's more, you can depend upon properly conditioned and inspected tank cars to insure trouble-free unloading and handling. Technical Service by Hooker assures you of experienced advice on the efficient, safe handling of chlorine and other Hooker Chemicals.

For copies of interesting and informative papers on bleaching listed here, please write on your business letterhead.



Send for This Helpful Bleaching Data

Bulletin No.

201 Process and Equipment for Making Bleach Liquor for Use Without Settling

211 Chemistry of Bleaching Chemical Wood Pulps

214 What Do We Know About Bleaching?

236 Importance of pH and Catalysts in Bleaching Operations

242 Production and Use of Unsettled Bleach Liquor

243 Procedures and Brightness Grades in Bleaching Sulfate Pulps

From the Salt of the Earth

HOOKER ELECTROCHEMICAL COMPANY

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units. Screw conveyors move the sludge from the discharge hoppers to a small steel collecting tank.

When the collecting tank becomes full of heavy sludge, an electrically driven pump starts automatically and discharges the collected wastes through one of two 300-foot pipe lines, which run under the river to a storage lagoon along the east bank of the river.

The basin is divided into two complete units, each capable of treating a normal flow of wastes from the plant. All the sludge collection and disposal equipment is installed in duplicate to protect the system against stoppages in case of breakdown.

In the event both sludge pumping units go down, because of a condition such as a power failure, a large emergency sludge storage tank will enable the system to continue operations for at least 24 hours.

Plant officials explained that a large part of the wastes, once discharged into the river, were eliminated several years ago when the plant increased its chemical recovery capacity and made operational improvements in the pulp and paper mills. The settling basin provides a final refinement for those waste waters not treated by internal controls.

J. Lynne Ferner, manager of the Wil iamsburg plant, explained that much of the pollution abatement equipment installed during the past three years has helped pay its way through the recovery of chemicals and fibers and by providing steam and heat for plant operations. Some costly installations, however, including the new settling basin and lagoons and dykes built in the past to keep wastes out of the river, bring no return, the plant manager pointed out.

* * *

The Lowell Textile Institute Research Foundation, Lowell, Mass., has been established on a nonprofit basis for the purpose of encouraging and administering research sponsored by industry and government. Problems dealing with the major sciences, engineering, and industrial economics in the fields of textiles, paper, leather, and related industries will be investigated.

The Department of Paper Technology at Lowell Textile Institute completed a summer course in June for twenty students, most of whom were employed by the paper and allied industries. Professor Geoffrey Broughton gave the more technical lectures. Other lectures included Paul Brown, Tileston & Hollingsworth Co.; C. W. Stillwell, Dennison Mfg. Co.; F. W. Partsch, J. O. Ross Engineering Corp.; R. O. Page and C. B. Mills, Courier-Citizen Co.; J. Dussault, A. P. Corrugated Box Corp.; and J. F. Wright, National Aniline Division. Plant visits were made to the Champion-International Co., Mead Corp., A. P. Corrugated Box Co., the Courier-Citizen Co., McLaurin-Jones Co., H. J. Dowd Co., the M.I.T. Dard Hunter Museum, and the Fabric Research Laboratories.

Pulp and paper summer course students at Lowell Textile Institute

* * *

John Fletcher, formerly of the Rohm & Haas Co. and the Glidden Co., has joined the research staff of Arthur D. Little, Inc., in Cambridge, Mass.

* * *

The Extension Service, Institute of Agricultural Sciences, The State College of Washington, Pullman, Wash., has issued an interesting and lengthy instruction 40-page publication (Extension Bulletin No. 440) on "Trees of Washington."

* * *

A residue left after making vanillin from sulphite waste liquor of the Marathon Corp., Rothschild, Wis., is used as an expander for negative plates in storage batteries. It makes these plates more porous, so that the battery acid penetrates throughout the plate instead of merely working on the surface. The effect is to get more useful work out of a battery and to make it last longer. About 85% of all batteries made in the United States are now made with this ingredient. More than half of all of the vanillin used in the United States is manufactured by the Salvo Chemical Co. from Marathon's spent liquor.

* * *

To reduce pollution of the Peshtigo River, Badger Paper Mills has recently installed a large sulphite liquor collection tank equipped to fill a 3000-gallon tank truck in $4^1/_2$ minutes. It has also acquired truck equipment for hauling and spreading this material as roadbinder. Applying sulphite roadbinder lays dust and provides a surface comparable to blacktop on roads made of soil fitted for this treatment. The cost to treat a mile of road varies between $50 and $150, principally according to the length of haul from the mill to the site. No charge for the liquor is made by the Badger mill.

* * *

The International Nickel Co., 67 Wall Street, New York 5, N. Y., has just issued a 34-page booklet "Practical Solutions for Metal Problems in Pulp and Paper Mills."

* * *

The Sveen Pederson Sales Corp., 35–21 Eleventh Street, Long Island City 6, N. Y., has just issued a new bulletin describing the Sveen Pederson Flotation Saveall.

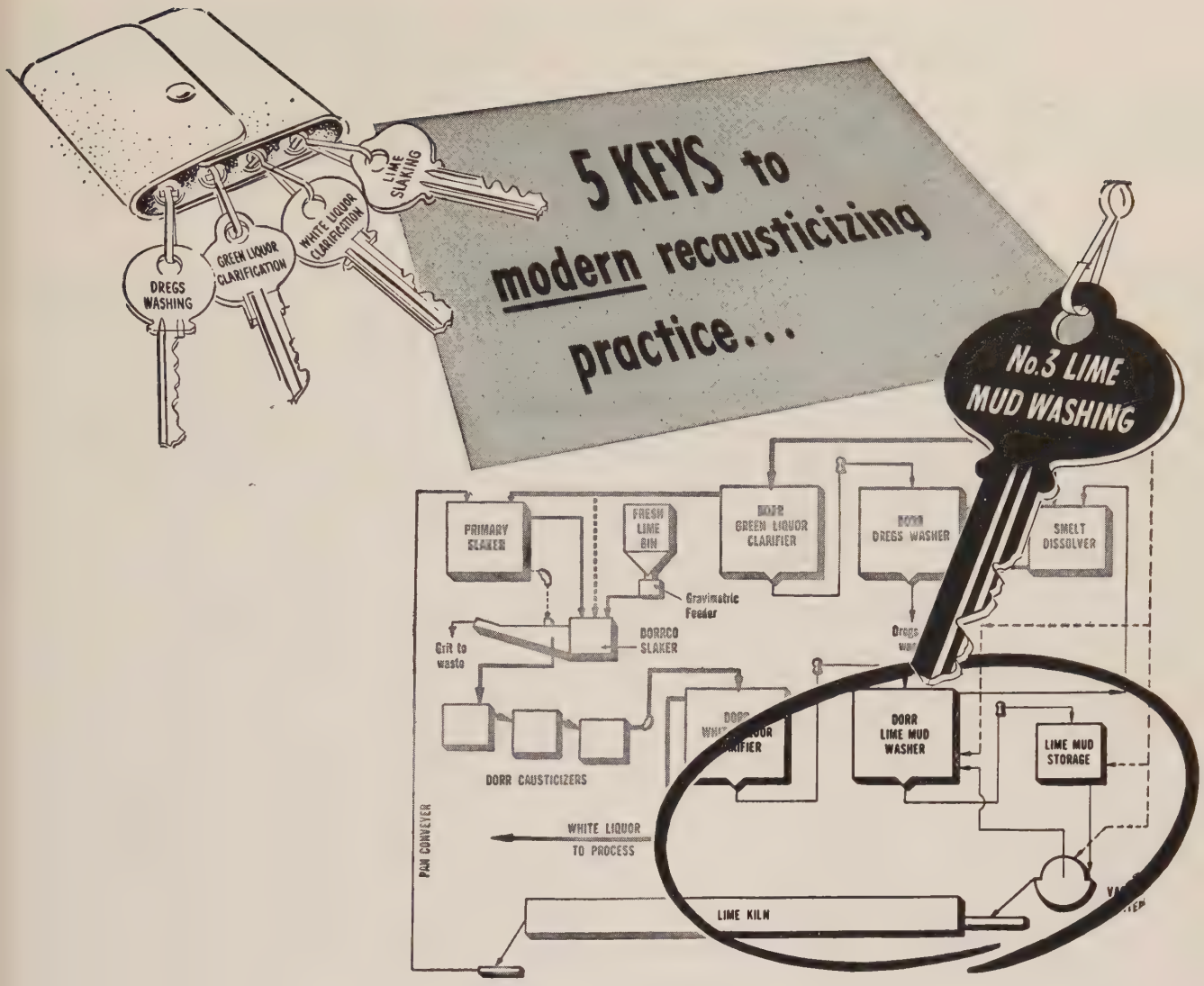
At a meeting of the Board of Directors the following officers of this company were elected: President, Odd Wennberg; Vice-President and Sales Manager, Paul Easton; Treasurer, William G. Weygand; Secretary, Newman Lawler. Paul Easton was formerly with the Hercules Powder Co. and the Bulkley, Dunton Pulp Co. Herman Berg has joined the staff as a sales and service engineer.

* * *

Ross Industries Corp. and the J. O. Ross Engineering Co. have merged. Both companies will hereafter operate as the J. O. Ross Engineering Corp. at 444 Madison Avenue, New York, N. Y.

* * *

A nine-member executive committee to be responsible for the University of Maine Pulp and Paper Foundation has been approved by the trustees of the University. J. L. Ober, Scott Paper Co., Chester, Pa., is Chairman. The other members are W. E. Parsons, Keyes Fibre Co., Waterville, Me.; F. A. Soderberg, General Dyestuff Corp., New York, N. Y.; P. S. Bolton, Robert Gair Co., Uncasville, Conn.; R. A. Wilkins, Bird & Son, East Walpole, Mass.; T. G. Managan, International Paper Co., Livermore Falls, Me.; J. B. Calkin,



Two stages of counter-current decantation washing of lime mud prior to filtration is now a standard design feature of the Dorr Continuous Recausticizing System. It produces a thoroughly washed lime mud which yields a filter cake feed to the kiln containing one-half of one percent soda expressed as Na_2O.

In practice this means . . .

- Increased chemical recovery.
- Improved filter and kiln operation.
- Longer life for kiln linings.

Two stage mud washing is only one of the important unit operations in The Dorr System. A new bulletin, #3301, describing the recausticizing operation in detail, will be sent on request. Address inquiries to The Dorr Company, Stamford, Conn.; or in Canada, to The Dorr Company, 80 Richmond Street West, Toronto 1.

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THE DORR COMPANY · ENGINEERS · STAMFORD, CONN.

Associated Companies and Representatives in the principal cities of the world

L. C. Jenness, and A. S. Campbell, University of Maine. The purposes of the Foundation are to provide financial assistance for undergraduates in the 5-year operational management course, and to advance fundamental and applied research in pulp and paper technology at the University, as well as to increase the teaching facilities in this field.

* * *

The Babcock & Wilcox Co., 85 Liberty Street, New York, N. Y., has taken five entire floors, totaling 120,000 square feet in the new 32-story Chrysler Bldg. East, in New York. The building will be occupied in the Fall of 1951.

* * *

The Minneapolis-Honeywell Regulator Co., Brown Instrument Division, Station 40, Wayne and Windrim Avenues, Philadelphia 44, Pa., is issuing a large number of Instrumentation Data Sheets. These may be obtained on request from S. D. Ross, Manager of the Editorial Section at the Brown Instrument Division.

* * *

The General Electric Co., Schenectady 5, N. Y., has issued a 28-page booklet entitled "Carbon Brushes for Electric Equipment" (Pub. G.E.A.-5597).

William V. O'Brien has been appointed manager of the G.E. Apparatus Marketing Div. at Schenectady.

A. T. Chaudonnet has been appointed Manager of the G.E. Turbine Div. at Lynn, Mass.

* * *

The American Cyanamid Co. is increasing its melamine production facilities at Willow Island, W. Va.

H. C. Milton has been appointed Asst. District Sales Manager of the Industrial Chemicals Division of American Cyanamid Co., at Boston, Mass.

* * *

Bauer Bros. Co., 1715 Sheridan Avenue, Springfield, Ohio, has issued an 8-page bulletin (No. 52) on "Machinery for the Process Industries." The bulletin explains the facilities of the Company to make test runs on commercial-size machines.

* * *

Raymond K. Hovel was recently appointed Works Manager of the Dilts Machine Works, Fulton, N. Y. He succeeds D. J. Kesterke who has entered another business.

* * *

The Black-Clawson Co., Hamilton, Ohio, has issued an 8-page bulletin (No. 1-BC) on "Drives." It describes the spiral bevel, hypoid, calender reversing, extended shaft, double-reduction, and inching drives.

* * *

Cole Coolidge has been appointed director of the Chemical Department of the du Pont Co. He succeeds Elmer K. Bolton, retired.

George E. Holbrook has been named assistant director of du Pont's Development Department.

* * *

A Department of Information Services has been formed by the Westinghouse Electric Corp., Pittsburgh, Pa. All functions of public relations, employee relations, and related activities will be included in this new section. Dale McFeatters has been appointed Director of Information.

* * *

Eugene S. Massey has been appointed technical sales representative in Cleveland, Ohio, for Hercules Powder Co.'s Synthetics Department. He will assist W. W. Trowel, Manager.

The establishment of the trade name "Kymene 138" for a wet-strength resin for paper has been announced by the Hercules Powder Co. This resin was formerly known as "Resin 138."

* * *

Clinton Foods, Inc., Clinton, Iowa, has elected Roscoe C. Wagner of the Corn Processing Division and Earl Millard of American Partition Corp. as members of its Board of Directors.

* * *

Clinton B. Burnett has been appointed Director of Engineering of Johns-Manville Corp., New York, N. Y. Mr. Burnett was formerly production manager of the company's Building Products Division.

* * *

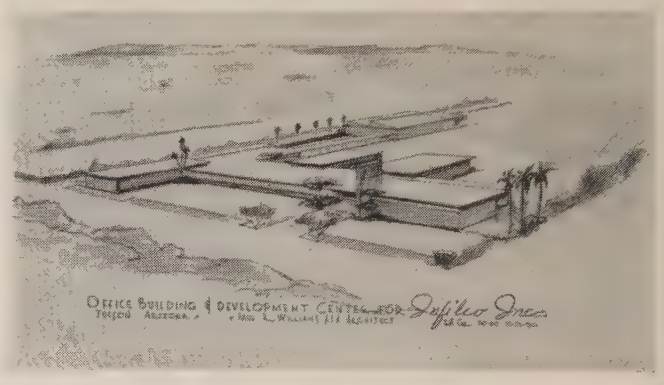
The Glidden Co. will spend $700,000 immediately to expand its production of alpha protein, used to make fiber boxes weatherproof. The output will be increased by 40%.

* * *

The Falk Corp., 3001 W. Canal Street, Milwaukee 8, Wis., has issued a 16-page bulletin (No. 10, 011) on "Power Transmission Equipment for the Pulp and Paper Industry."

* * *

Infilco, Inc., Tucson, Ariz., has issued Bulletin 50 I on "Products and Processes for Industry." It contains a number of case histories relating to water treatment.



Office building and development center for Infilco, Inc., Tucson, Ariz.

Infilco has started construction of its new headquarters building at Tucson. It will occupy 7½ acres, house 200 employees, and cost $400,000.

* * *

K. S. Le Baron has been appointed manager of pulp and paper sales for John Inglis Co., Ltd., Toronto, Ont. Mr. Le Baron was formerly with the St. Lawrence Paper Mills, Dryden Paper Co., and the Canadian International Paper Co. For the past five years he was Montreal District Manager for John Inglis Co., Ltd.

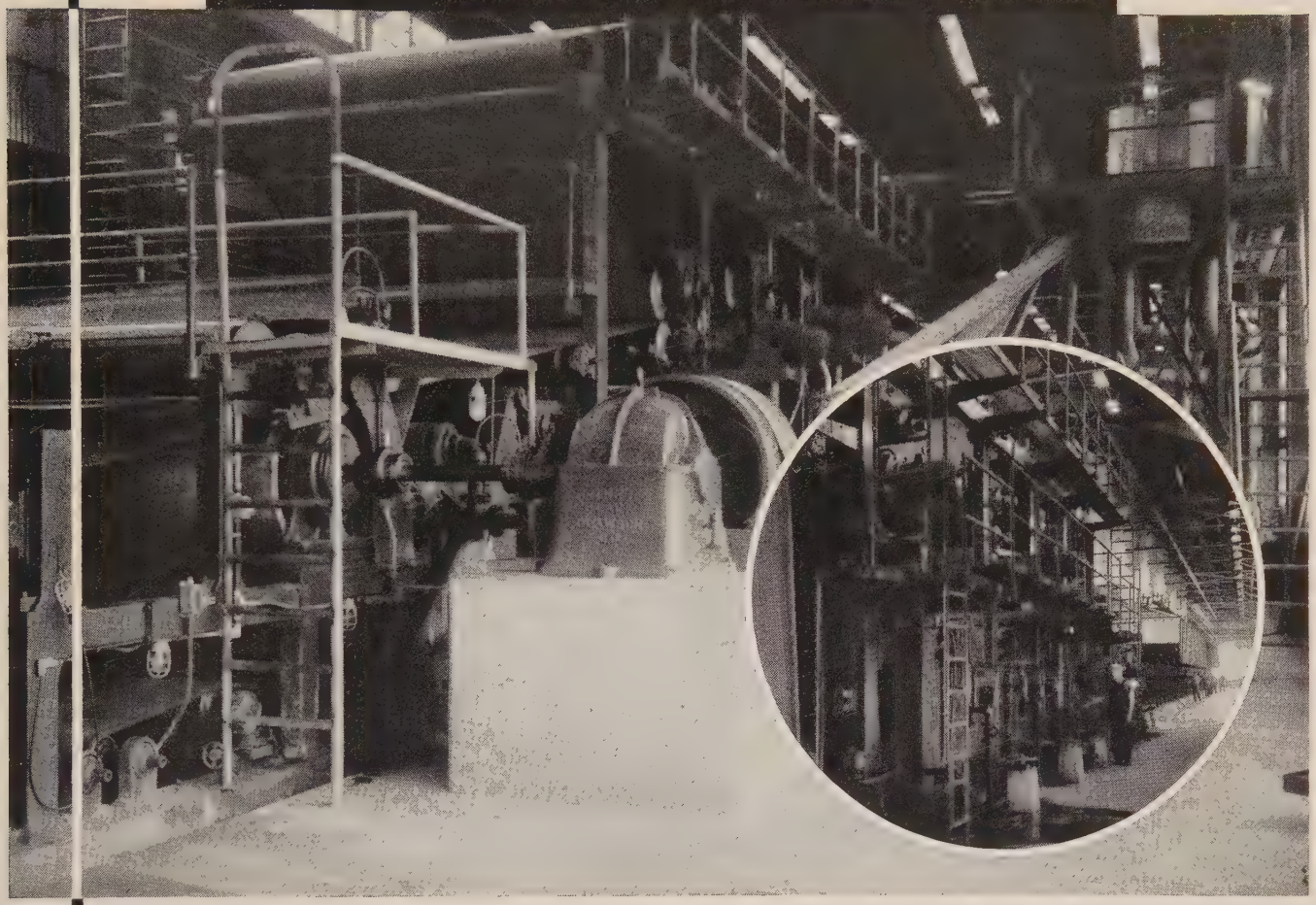
* * *

James P. Stewart and Wencel A. Neumann, Jr., have been elected President and Vice-President in charge of Industrial Sales, respectively, of the De Laval Steam Turbine Co., Trenton, N. J.

* * *

The Atlas Mineral Products Co., Mertztown, Pa., has announced a new product Ampreg E, a thermosetting synthetic resin impregnant specifically designed for application to concrete and porous castings. It may be applied by brush or dip coat methods. It has resistance to chlorine dioxide and sodium hypochlorite (Bulletin 5-60 A).

Latest Design and Remote Control Features Incorporated in the B-C Press Section



● Because remote control of equipment is the outstanding forward step in paper making since the war, Black-Clawson has gone "all the way."

A Black-Clawson press section with the primaries superimposed over the vat section available with remote control of practically every operation.

Loading and lifting of press rolls —by remote control. Motor operated oscillating doctors with broke conveyors. Push button operation of felt stretchers. Air operated clutches on press drives. Air operated felt guides.

Discuss this press—the entire machine in fact—from the standpoint of remote control operation with our representative on his next call.

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Associate: THE ALEXANDER FLECK LTD., Ottawa, Ont. • *Subsidiary:* B-C INTERNATIONAL LTD., Greener House, Haymarket, London, S. W. 1, Eng.

James Mair, Vice-President of the Goslin-Birmingham Mfg. Co., Birmingham, Ala., was awarded the professional degree of Chemical Engineer by the University of Alabama on June 5. His thesis was written on the subject of "The Falling Film Evaporator."

* * *

Commercial production of a new, more convenient form of Mersize has been announced by the Monsanto Chemical Co., Everett, Mass. The product designated as Mersize R M eliminates mixing operations.

* * *

The James Brinkley Co., Seattle, Wash., has been appointed Pacific Coast representative for G. D. Jenssen Co., Inc., Watertown, N. Y.

* * *

Henry C. Speel has been appointed Director of the Development Department of Wyandotte Chemicals Corp., Wyandotte, Mich. Mr. Speel was formerly with the General Dyestuff Corp. He is an expert on surface-active agents and natural colloids.

* * *

William F. Scanlan has been transferred to the Houston, Tex., office of the Swenson Evaporator Co. During the past four years he has worked out at Whiting, Ind., for the Chemical and Pulp and Paper Divisions.

* * *

Madav R. Bhagwat, formerly of the H. K. Ferguson Co., has joined the research department of the Hooker Electrochemical Co., Niagara Falls, N. Y.

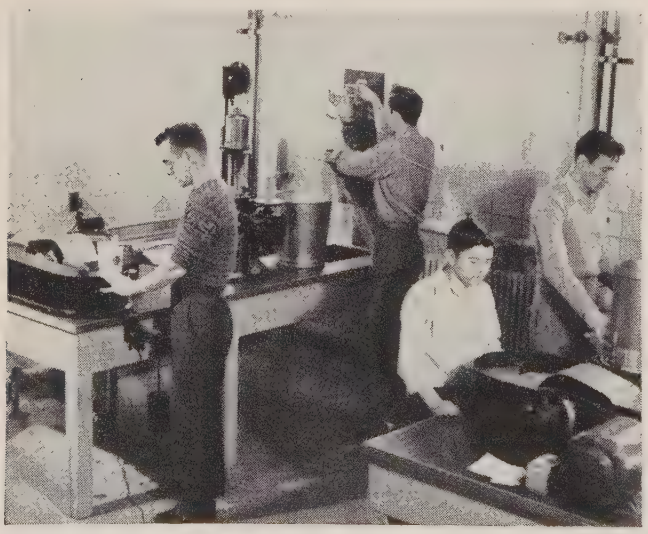
* * *

The Chicago Bridge & Iron Co., 332 South Michigan Avenue, Chicago 4, Ill., has issued an 8-page bulletin (No. 9) on "The Phoscote Process" which contains information on the pickling and painting of steel plates, angles, channels, and other shapes produced by rolling.

* * *

The first students to complete the course in the new Pulp and Paper school of Western Michigan College of Education, Kalamazoo, Mich., were graduated this June. All were placed immediately in jobs for which their training had prepared them.

They were located as follows: Donald L. Hayser, Allied Paper Mills, Kalamazoo, Mich.; Wilbur L. Kite, Lee Paper Co., Vicksburg, Mich.; Elton T. Krogel, Watervliet Paper Co., Watervliet, Mich.; Roger L. McVickar, Otsego Falls Paper Mills, Inc., Otsego, Mich.; Wilbur L. Noel, Kalamazoo Paper Co., Kalamazoo, Mich.; Edward E. Stephenson, Sutherland Paper Co., Kalamazoo, Mich.; Wyman F. Uhl, American Coating Mills, Elkhart, Ind.; Raymond C. Wagner, National Gypsum Co., Kalamazoo, Mich.



Pulp & Paper Dept. Western Michigan College. Laboratory for evaluation of pulp showing: precision beaters, sheet mold, disintegrator, freeness testing devices.

* * *

The possibilities for expansion of the pulp and paper industry in the United States and Alaska were presented by H. R. Josephson, Forest Service, U. S. Department of Agriculture, before the Forestry Committee of the APPA. Mr. Josephson's remarks follow:

"Possibilities for expansion of the pulp industry are analyzed in this discussion solely in terms of pulpwood and water resources. Other relevant factors such as availability and cost of plant equipment, supplies, labor, financing, power, transportation, and marketing are not considered herein.

"One of the most promising regions for expansion of the pulp and paper industry is the southern pine region, which now provides somewhat more than half of the total pulpwood harvested in the United States. The recent spectacular expansion of the industry in this region is still continuing, with construction of a number of new mills and additional plant facilities currently under way.

"An important forestry problem facing the pulp industry in this region is the marked dependency on southern pine. Consumption of hardwood pulpwood is increasing slowly, but still accounts for only about 10% of the pulpwood cut in the South.

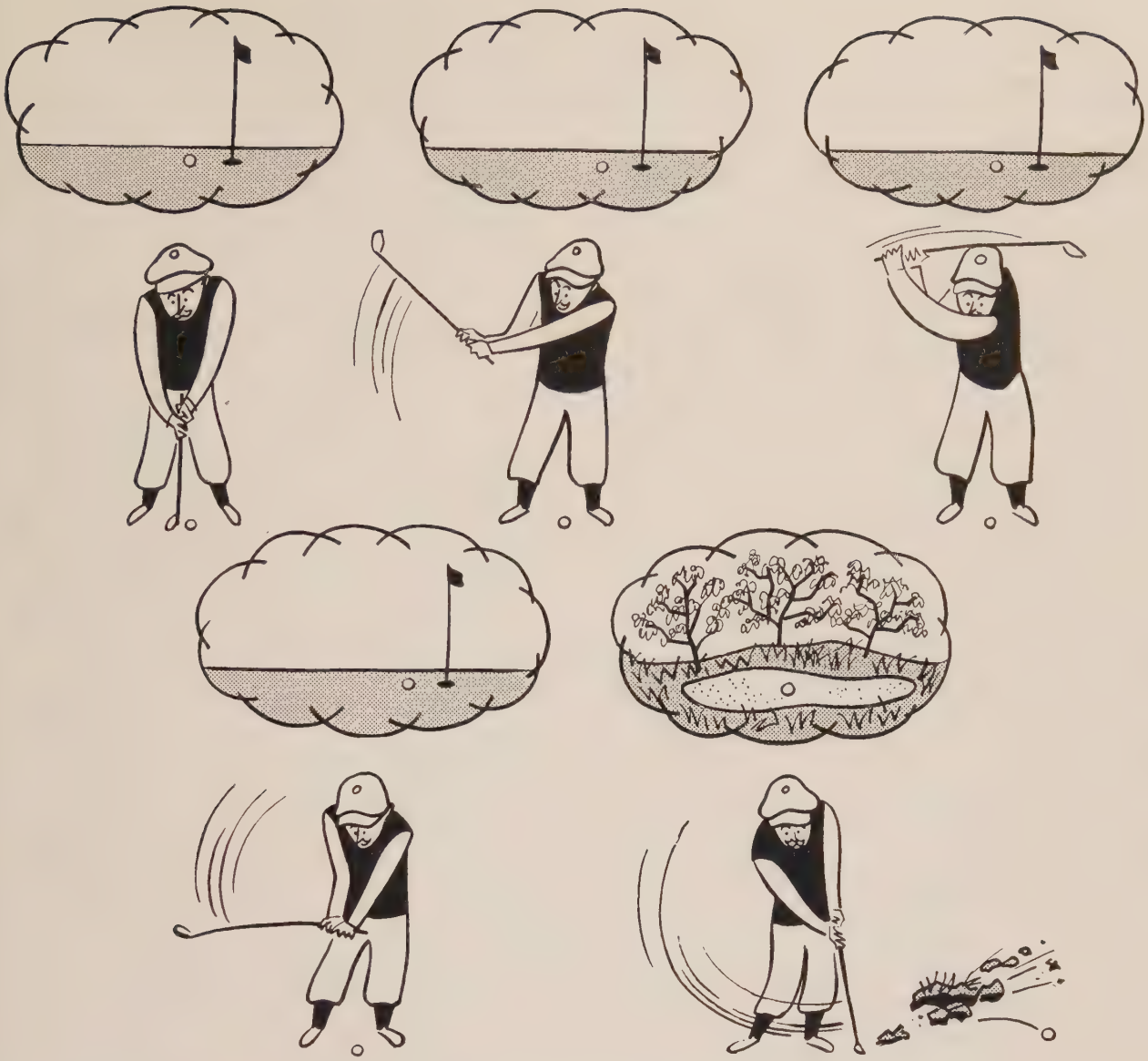
"Another basic problem of the pulp industry, of increasing importance, is the direct competition with the lumber industry and other forest industries for the available pine timber. It is estimated that 70% or more of the pulpwood cut is from saw-timber size trees. Conversely, considerable lumber is cut from pine pole timber trees of less than 9 inches in diameter. Many areas cut for sawlogs are indistinguishable from other areas cut for pulpwood.

"Wide variations are found in local timber supply situations, with timber resources declining in many areas and building up in others. Recent results of the Forest Survey show that in the 13-year period, 1935–48, the total volume of pine in trees above 5 inches d.b.h. dropped 4% in Florida, 8% in South Carolina, and 20% in Mississippi. In the same period hardwood volumes dropped 15% in Florida and 2% in South Carolina, with no change in Mississippi. Volumes of the larger sizes and higher quality trees have shown a particularly sharp drop as a result of concentrated cutting of the higher value trees. Along with the decline in timber volumes in these states has been a general invasion of hardwoods, especially of sapling size of less than 5 inches in diameter.

"In contrast to the general decline in all timber volumes, particularly saw-timber, the Forest Survey also showed that volumes of pole-size pine trees have been increasing in South Carolina and Florida. Likewise in contrast to the general 13-year trend, in 1946–48 there was a surplus of total pine growth in South Carolina and Florida, largely reflecting improved fire protection and reduced mortality. In Mississippi, on the other hand, pole timber volumes as well as saw-timber volumes decreased in the 13-year period between surveys, and the current growth is still less than drain.

"There is thus wide variation in forest conditions between states. Such variations are also marked within states, as in South Carolina where the Survey showed a surplus of pine growth in the Piedmont but heavy overcutting in the Coastal Plain. Even where there is a current surplus of growth prospective increases in drain may indicate that such conditions are only temporary unless accelerated action is taken to improve forest conditions.

"There are several means by which further expansion of the pulp industry in the South may be supported. Expansion may be achieved at the expense of the lumber industry



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We got that from an old duffer we know.
He'd say, "If you want to get some place on a course
you've got to know where you want to go.
And that takes thinking ahead."

And when your production capacity hinges on
process materials like soda ash, we think it makes sense
to think ahead about a reliable source of supply.

If we can't sell you any soda ash now,
it's because we're serving our customers of record.
But we'll be glad to "think a stroke ahead" with you.
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through acquisition of land and timber that might otherwise be utilized by sawmills. Prospective increases in competition for timber will undoubtedly involve higher pulpwood prices since pulpwood stumpage selling for $3.00 per cord may bring the equivalent of $7.00 per cord when utilized for sawlogs. Because of certain competitive advantages for the pulp industries, the lumber industry and other plants needing higher quality materials will undoubtedly be hit hardest in the competition for wood.

"A second means of expanding pulpwood resources is through increased use of woods and mill waste. Studies indicate that as much as one half cord of chippable waste is produced for each thousand board feet of lumber cut. Some of this material is now utilized for fuel; a great deal of it is currently unavailable because of the high costs of collection and debarking. However, possibly one to one and one-half million cords of such mill waste might be made available to the pulp industry in the South. In the woods progress has been made in utilizing material formerly wasted. Tops now make up as much as 16% of the pulpwood cut in Florida, for example. There is a large opportunity for use of additional tops, thinnings, and other forms of timber now wasted in the woods.

"A third means for expanding pulpwood supplies lies in greater use of hardwoods, which make up about one half of the standing timber in the South but account for only one third of the drain. Large volumes of cull trees, mainly hardwoods, could provide millions of cords annually. Mortality of hardwoods and pine amounts to as much as 13 million cords annually, some of which could be salvaged by thinnings. The readily available hardwoods could support a tremendous expansion of pulp production, particularly of semichemical and dissolving pulps.

"A fourth means for expansion of special long-run importance involves the acquisition and management of lands for timber production. Pulp companies now hold over 8 million acres of forest land in the South and although purchase of desirable holdings is becoming increasingly difficult acquisition is continuing. Timber growth can be stepped up considerably through improved protection against fire, more intensive management, and establishment of plantations. However, since most pulpwood originates on lands not owned by pulp companies, the industry has in addition a keen interest in educational and other forestry programs to stimulate better management by other timber owners.

"With respect to the factor of water supply, there is need to consider carefully local conditions in any plans for pulp mill expansion. To insure safe minimum yields of water in many areas will require reservoir construction, which will of course add to production costs. Ground water supplies are limited in many areas, and in the Coastal Plain region may be subject to salt-water intrusion if drawn upon too heavily. Pollution is an increasingly important problem, both to pulp mills affected by other industries and, conversely, to communities and plants affected by the effluent of pulp mills. There is a general trend toward stricter control of water pollution, with consequent impacts on water costs.

"While there are still many potential sites where adequate water is available there is need for critical appraisals of water supplies to minimize costs of developing and maintaining flows of suitable water. The industry has an interest in many of the multipurpose development programs for river systems, and each plant has a specific interest in land management programs on its particular watershed. In many situations, pulp companies may be able to manage their properties most efficiently for both pulpwood and water.

"As a general summary regarding the South, it is believed that there are still a number of local areas where timber supplies and water resources will support additional pulp mills. Exact locations will, of course, require careful consideration of many interrelated factors. Sound expansion of the industry with minimum impacts upon other industries which compete for the available timbers will require increasing attention to better utilization of timber now wasted in mills and in the woods, expanded use of hardwoods, and acquisition and management of forest lands for increased production of timber crops.

"The West Coast region of Oregon and Washington also offers a number of promising possibilities for expansion of the pulp industry. As in the South, there is growing competition for timber in this area but here too the pulp industry has a competitive edge based in part on its ability to utilize lower quality material and species in limited demand by other industries.

"One of the important determinants of the outlook for an expanded pulp industry is the degree of integration achieved with the lumber and other timber industries to permit utilization of mill and woods waste. There are tremendous volumes of excellent pulpwood still unutilized on logging operations, and to a lesser extent in mills. Greater use of such material would support a substantial expansion of pulping capacity in the West. The extent of timber acquisition by pulp companies will also greatly influence the outlook for the industry. As in the South, many pulp companies have adopted aggressive land acquisition policies and have instituted management practices for long-term production of timber.

"Abundant water supplies are available in many sections of western Oregon and Washington. In most parts of California, however, and in much of the Rocky Mountain area shortages of suitable water supplies constitute a limiting factor to pulp mill development.

"From the standpoint of available timber supplies and suitable water, there are several promising possibilities for development of kraft pulp mills, chiefly in western Oregon, providing new mills depend rather heavily upon Douglas-fir waste and low-grade logs and upon lodgepole pine. There are also some opportunities for expansion of sulphite pulp production based primarily upon use of hemlock and fir from the higher elevations. Several hardwood pulp mills using semi-

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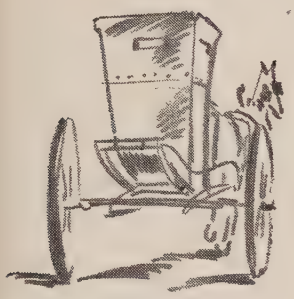
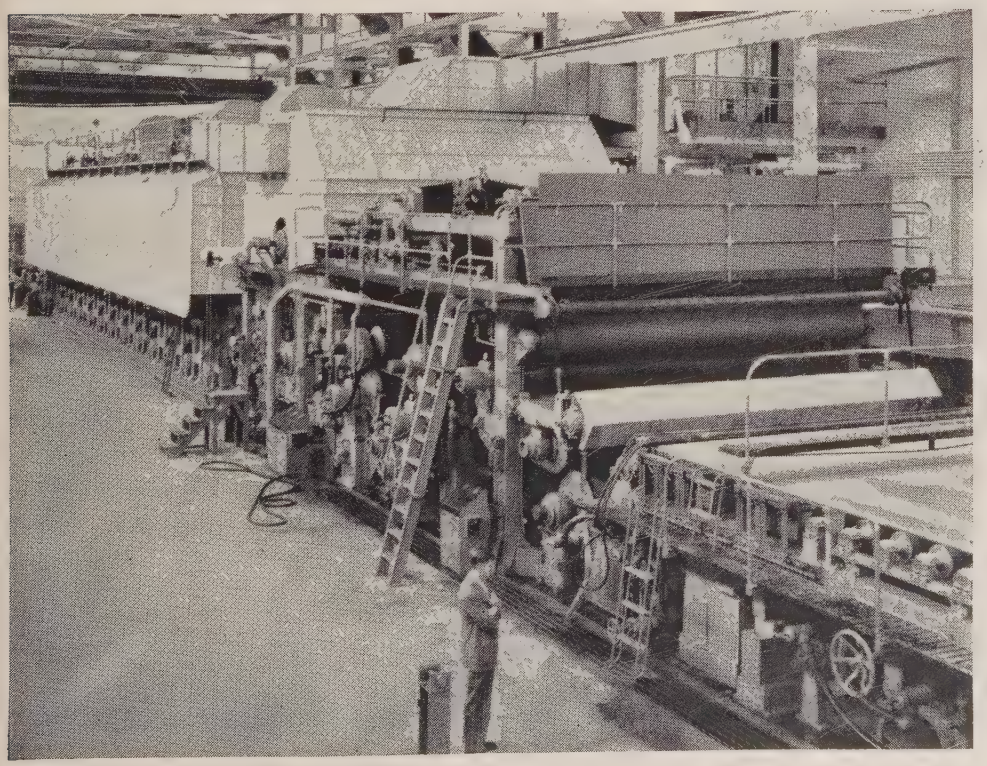


Do you recall . . .

Oliver Wendell Holmes' story of the "Wonderful One Hoss Shay"? It was built by a deacon who had observed that most carriages broke down in one part sooner than the other. He vowed that he would build a carriage equally strong in all parts so that nothing would break first. He succeeded so well that the One Hoss Shay lasted one hundred years to the day.

The parallel is that our machines are equally well built in all of their component parts. You can expect long and unusual trouble-free service from a Rice Barton machine—the whole being a well-integrated piece of workmanship like the One Hoss Shay—without any weak part.



Fourdrinier Paper Machines
Cylinder Paper Machines
Pulp Drying Machines
Miniature Paper Machines
McDonnell Fourdriniers
Harper Fourdriniers
Removable Fourdriniers
Suction Presses
Dual Presses
Size Presses
Smooth Presses
Open Dryers
Minton Vacuum Dryers
Slat Dryers
Barber Dryers
Yankee Dryers
Breaker Stacks
Calenders
Pope Reels
Upright Reels
Revolving Reels
Slitters
Winders
Hypoid Gear Drives
Cut Tooth Spur Gears
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Pasting Machines
Waxing Machines
Shake Heads
Suction Box Oscillators
Suction Box Covers
Paper Mill Rolls—All Types
Suction Rolls
Stone Rolls
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Cooling Rolls
Cram Drainage Systems
Cram Siphons
Steam Joints
Doctors
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Lannoye Pulpers
Agitators for Vertical Chests

chemical or caustic processes could be based upon available supplies of alder. In the northern Rocky Mountain region, and in limited areas in the southern Rocky Mountains, there are also situations where timber and water supplies are adequate to permit establishment of new pulp mills.

"Large volumes of western hemlock together with adequate supplies of water are available in the national forests of southeastern Alaska. These forests could supply annually as much as two million cords of excellent pulpwood on a sustained yield basis. One large contract has been signed for use of Alaskan timber by a projected pulp mill in southeastern Alaska. However, various factors other than wood and water supply tend to limit development in this region and it is probable that immediate future expansion of the pulp industry may occur in other regions such as the South and the Pacific Northwest where conditions have already led to development of a substantial pulp industry."

OBITUARIES

George E. Williamson

George E. Williamson, President and Chairman of the Board, Strathmore Paper Co., West Springfield, Mass., died on Tuesday, July 3, in Des Moines, Iowa, while on a business trip.

Mr. Williamson was born on Sept. 11, 1878, in Worcester, Mass., and graduated from the Worcester Polytechnic Institute in 1900 with a degree of bachelor of science in chemistry. In 1901 he took postgraduate courses in mechanical and electrical engineering. In 1950 he was awarded the honorary degree of doctor of engineering.

George E. Williamson

Mr. Williamson's first job after leaving college was as a tour worker at the American Writing Paper Co. mill in Holyoke, Mass. At that time a tour duty consisted of an 11-hour day or 13-hour night, 6 days a week, and wages were $1.50 per day or night.

After working a few months at the American Writing Paper Co., Mr. Williamson became connected with the Union Metallic Cartridge Co., Bridgeport, Conn., as a chemist, production foreman, head of the mechanical department, and finally as engineer of the works, which position he held from 1902 until 1911.

In November, 1911, he joined the Strathmore Paper Co. in West Springfield, Mass., as chief engineer. He held this position until he was appointed assistant to the President in February, 1926. In January, 1928, he was elected Treasurer, remaining in that position until December, 1942, when he was elected Vice-President and Treasurer. In February, 1946, he was elected President and continued in that position until the time of his death. He was a director of Strathmore since 1926.

Mr. Williamson was a charter member of the Technical Association of the Pulp and Paper Industry and was its President in 1921 and 1922. For many years, until the time of his death, he was Chairman of the Joint Text Book Committee, which is responsible for the administration of the textbooks on the Manufacture of Pulp and Paper published by the McGraw-Hill Book Co.

William MacClean Shoemaker, Jr.

William M. Shoemaker died suddenly at his home, Sunny Acres, Kennett Square, Pa., on Monday, July 30.

Mr. Shoemaker was born on Feb. 7, 1895, in Norristown, Pa., and graduated in 1917 as a mechanical engineer from Swarthmore College. From 1919 to 1946 he was Secretary and Production Superintendent of the National Vulcanized Fibre Co., Yorklyn, Del. In 1946 he joined the Douglas T. Sterling Co. of Stamford, Conn., as an industrial engineer; and was a consulting engineer in Kennett Square, Pa.

For the past two years he has been a broker of specialty foods in Tucson, Ariz. From 1937–1939 Mr. Shoemaker was a member of the Executive Committee of the Technical Association of the Pulp and Paper Industry.

He is survived by his wife, Mary Gawthrop Shoemaker, two sons, William G. and Charles G., of Kennett Square; and a daughter, Mrs. William J. Turner, Oswego, Ore.

Harold Francis Cotter

Harold F. Cotter died suddenly on April 30. He was Professor of Chemistry at the University of Alabama since 1938.

Mr. Cotter was born at Boston, Mass., on Nov. 17, 1902, and graduated from the Massachusetts Institute of Technology in 1923. He was employed by the Penobscot Chemical Fibre Co., Great Works, Me., in 1924–1925. From 1925 to 1935 he was a chemical engineer for the Bureau of Tests, International Paper Co., Glens Falls, N. Y. From 1935 to 1938 he was with the Sturtevant Mill Co., Boston, Mass., and joined the University of Alabama as Professor of Pulp and Paper in 1938.

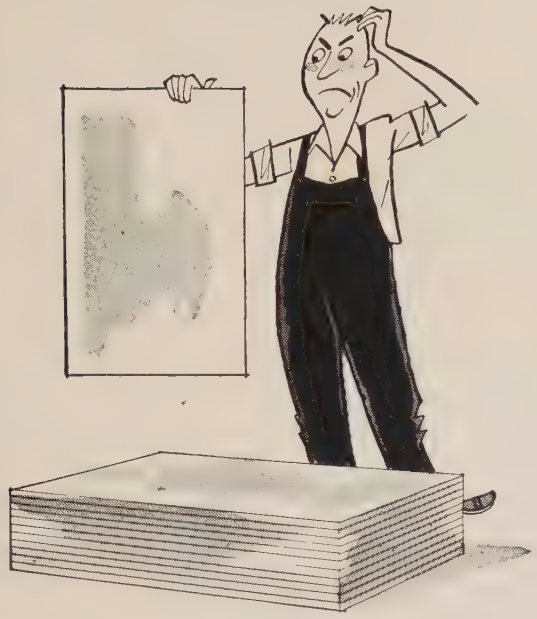
He was a member of the Technical Association of the Pulp and Paper Industry. His widow and twin sons survive him.

F. Paul Birk

F. Paul Birk, consulting paper mill engineer of Chicago, Ill., died suddenly of a cerebral hemorrhage on June 19, 1951.

Mr. Birk was born in Chicago on July 29, 1901, and studied civil engineering at Chicago Technical College. From 1917 to 1930 he was associated with James L. Carey, Paper Mill Engineer, in Chicago. From 1934 to 1939 he was a civil engineer for the Sanitary District of Chicago. In 1939–40 he was a civil engineer for the Chicago Department of Subways and Superhighways. From 1940 to 1944 he was a mechanical engineer for Albert Kahn, Inc., in Detroit. From 1944 to 1946 he designed and built the N. Rochester, N. H., mill of Spaulding Fibre Co. He became a partner in the firm of Birk & Choporis in Chicago and in 1947 established his own consulting engineering firm.

He resided in Glen Ellyn, Ill., and is survived by his wife, Dorothy (nee Gough).



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It will pay you to let a Celite engineer make on-the-spot recommendations for the proper use of Celite to make your white pigments go further. He will also acquaint you with other important Celite advantages that may help you turn out better paper at lower cost. Contact Johns-Manville, Box 290, New York 16, N. Y. In Canada, Canadian Johns-Manville Co., Ltd., 199 Bay Street, Toronto 1, Ontario.

If you are using . . .	Celite substitution suggested for equal or better dry brightness or opacity
Up to 2% TiO_2	Add 1% to 5% Celite 263 or Celite 388
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FOR THE PAPER INDUSTRY

ASSOCIATION NEWS AND EVENTS

Plastics Conference

The Plastics Conference is scheduled to be held in Marshall Hall, College of Forestry, State University of New York, Syracuse, N. Y., on Oct. 25–26, 1951. The program of each day will be devoted to a broad subject. One day will be devoted to polymer coatings. The subject for the second day will be announced soon. Papers are planned for each morning session and a general round-table discussion for the afternoon. The final program will be published in the September issue of *Tappi*. E. C. Jahn, Chairman of the Plastics Committee, will be General Chairman of the Conference.

Report of Nominating Committee

The TAPPI 1952 Nominating Committee, consisting of Vernon L. Tipka, Chairman, Newsprint Service Bureau, New York, N. Y., Nathan L. Malcove, Northern Paper Mills, Green Bay, Wis., Henry Vranian, Chesapeake Corp., West Point, Va., H. E. Pratt, Pejepscot Paper Co., Brunswick, Me., and N. R. Phillips, Champion Paper & Fibre Co., Canton, N. C., have presented the following nominees for officers and executive committeemen to be voted on by the membership prior to the TAPPI Annual Meeting in 1952:

President (one year): Kenneth P. Geohegan, Howard Paper Mills, Dayton, Ohio

Vice-President (one year): George H. Pringle, Mead Corp., Chillicothe, Ohio

Executive Committeemen (three years): George A. Day, Brown Co., Berlin, N. H.; Lewis K. Burnett, Ohio Boxboard Co., Rittman, Ohio; James R. Lientz, Union Bag & Paper Corp., Savannah, Ga.; Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wis.

Note: Article VII, Sec. 3, TAPPI Constitution: "Other nominations, if signed by at least 25 voting members, may be submitted to the Secretary of the Association, in writing, on or before November 20, and if each nomination so made is accepted in writing by the nominee, the name shall be placed on the official ballot."

Alkaline Pulping Conference

The Alkaline Pulping Conference will be held at the John Marshall Hotel, Richmond, Va., on Sept. 26–28, 1951. Henry Vranian of the Chesapeake Corp. of Va., West Point, Va., is general chairman and Robert R. Fuller, Gulf States Paper Co., Tuscaloosa, Ala., program chairman. Following is the tentative program:

Meeting of Wednesday, September 26

9:30 a.m. Virginia Room (Henry Vranian, Chairman)

1. "The Cellulosic Raw Materials Situation," by James W. Cruikshank, U. S. Forest Service, Ashville, N. C.
2. "Checking Wood Quality," by M. Klein and J. M. Ralson, Union Bag & Paper Corp., Savannah, Ga.
3. "Chipping Operations," by Vance P. Edwardes, Consultant, Corinth, N. Y.
4. "Effect of Chipping Knife on Wood Conservation," by Harold F. Wood, Jr., Heppenstall Co., Pittsburgh, Pa.
5. "Usable Waste in the Woods," by J. J. Armstrong, Union Bag & Paper Corp., Savannah, Ga.
6. "Possibilities in Forest Management," Speaker to be announced.
7. "Wood Losses in Chipper Operation," Speaker to be announced.
8. "Barking and Chipping Hardwoods," Speaker to be announced.
9. "Bark Burning" by Robert E. Elwanger, Chesapeake Corp. of Va., West Point, Va.
10. "Coating Ingredients in Tall Oil," by C. R. Outterson, and N. G. Selden, Albemarle Paper Mfg. Co., Richmond, Va., and J. W. Eldridge, University of Virginia, Blacksburg, Va.
11. "Flash Drying of Lime Kiln Feed," by Henry Vranian, Chesapeake Corp. of Va., West Point, Va.

12:30 p.m. Luncheon, Roof Garden (Speaker to be announced)

2:00 p.m. Virginia Room (Henry Vranian, Chairman)

1. "Hard Cooking of Northern Wood," by John P. Lunderville, Pulp Mill Superintendent, Brompton Pulp & Paper Co., Red Rock, Ont.
2. "Cooking of Knots and Rejects," by K. G. Chesley, Crossett Lumber Co., Crossett, Ark.
3. "Discussion of Controls, Circulation, and Indirect Heaters," by Robert Bowen, North Carolina Pulp Co., Plymouth, N. C.
4. "Effect of Bark in Sulphate Pulping of Slash Pine," by J. S. Martin and K. J. Brown, Forest Products Laboratory, Madison, Wis.

Meeting of September 27

9:30 a.m. Virginia Room (Robert R. Fuller, Chairman)

1. "Quality of Paper from the Sutherland High Yield Sulphate System," by Douglas G. Sutherland, Sutherland Refiner Corp., Trenton, N. J.
2. "Chemical Reaction Equilibria in the Combustion of Sodium-Base Pulping Liquors," by Malcolm N. May, Institute of Paper Chemistry, Appleton, Wis.
3. "Cooking Southern Wood for High Brightness Bleached Sulphate Pulp," by Malcolm B. Pineo, Brunswick Pulp & Paper Co., Brunswick, Ga.
4. "Neutral Sulphite Semichemical Pulping," by Richard G. Cokey, Vice-President, Sonoco Products Co., Hartsville, S. C.
5. "Semichemical Pulping and Wood Species," by J. N. McGovern and E. L. Keller, Forest Products Laboratory, Madison, Wis.
6. "Scandinavian Pulping Practices," Speaker to be announced.
7. "Review of Methods of Determining Degree of Pulping," Speaker to be announced.

12:30 p.m. Luncheon, Roof Garden (Speaker to be announced)

2:00 p.m. Virginia Room (Robert R. Fuller, Chairman)

1. Panel Discussion on Pulping: Participants—individuals who have presented papers and representatives of equipment companies, pulp manufacturers, instrument companies, research organizations, and bleacheries.

Program of September 28

1. Visit to the mill of the Chesapeake Corp. of Va. at West Point, Va.
2. Luncheon and Visit to the famous Colonial Village at Williamstown, Va.

Individuals who may wish to visit other mills such as the Continental Can Co. at Hopewell, Va., and the Albermarle Paper Co. and other mills in and near Richmond will be welcome. Arrangements should be made prior to the visit with the management of these companies.

Sixth Engineering Conference

The official mill visits during the Sixth Engineering Conference of the Pulp and Paper Industry to be held at Savannah, Ga., on Oct. 15–18, 1951, will be to the mills of the Union Bag & Paper Corp. at Savannah, Ga., and the Southern Paperboard Co., at Port Wentworth.

The following interesting information gives the high lights concerning Union Bag's operation in Savannah:

Plant History: Began operations September, 1936. Plant is now recognized as the "World's largest integrated kraft container plant." Major products are kraft paper, paperboard, bags, and boxes.

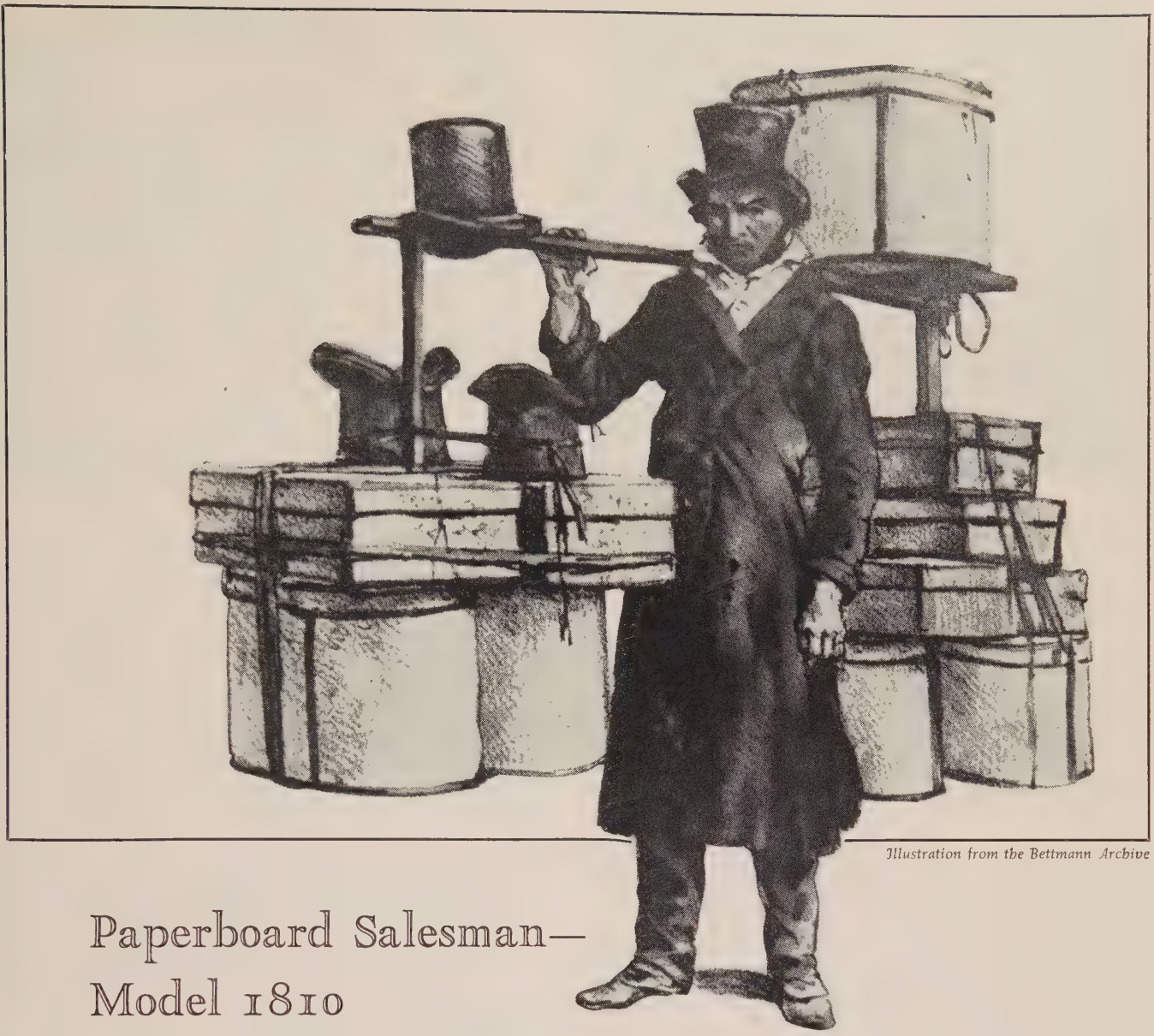


Illustration from the Bettmann Archive

Paperboard Salesman— Model 1810

The French, mindful of their finery, were the first to fashion sturdy boxes of paperboard for ladies' and gentlemen's hats. Built up by hand from multiple layers of paper, the board was shaped and moulded into boxes, some of them finished with a plain glazed surface, some with decorations. Then the salesman with his loaded display of paperboard boxes would call his wares through the streets of Paris.

Hat boxes, not much changed in design after 140 years, are still widely used for millinery and men's hats. But the once precious paperboard, now produced by modern high-speed methods, low in cost and plentiful, today protects just about every commodity used by business and the home. For packaging, for shipping, for sanitary protection, for display, for convenience, paperboard cartons and containers are the indispensable carriers of modern merchandise. No wonder paperboard accounts for nearly one-half the total production of the American pulp and paper industry.

The dramatic story of paper is told in the sound-and-color film, "Paper — Pacemaker of Progress," and in a book under the same title. Both are presented by F. C. Huyck & Sons as a tribute to the Paper Industry. The book will be sent free upon request.

KENWOOD WOOL PRODUCTS

HUYCK *Felts*

F. C. HUYCK & SONS • *Kenwood Mills* • RENSSELAER, N. Y.

Photo, Courtesy J. M. Huber Corporation

Single Instrument Measures Smoothness, Porosity and Softness of Paper

You just interchange the lower test plates in the GURLEY-HILL S-P-S Tester to convert it into an instrument for testing either smoothness, porosity or softness of any type of paper, by measuring a given air-leakage over or through the paper.

This 3 in 1 laboratory "assistant" is simple to operate, quick and accurate, and a real utility instrument where printing quality of paper must be reliably measured.

Bulletin No. 1400 describes the S-P-S Tester as well as other Gurley paper testing instruments. It's worth writing for today. W. & L. E. Gurley, Station Plaza & Fulton Sts., Troy, New York.

Basic Raw Material: The pine tree provides the plant with its basic raw material. On an average 2000 cords of pulpwood are used daily. This wood is obtained from the forests of Georgia, South Carolina, and Florida. Average cost of wood per year is nine million dollars. Wood is received in rail cars, trucks, and barges. Plant uses only pine wood, which has longer and stronger fibers than hardwoods. Any species of pine can be used. Pulpwood bolts are 5 feet, 3 inches long. Company has 700,000 acres of forest land. Buys 85% of its wood requirements from farmers and other landowners.

Pulp and Paper Mill: During 1949, pulp mill produced 371,624 tons of slush pulp from which the paper mill produced 361,112 tons of paper and paperboard. (This paper and paperboard would girdle the earth with a belt 238 feet wide.) Paper mill produces about 1250 tons of paper and paperboard every 24 hours. Pulp and paper mill operates 24 hours a day, 7 days a week.

By-Products: In 1949, by-products included more than 32,000 tons of crude black liquor soap (from which tall oil is made), more than 25,000 tons of tall oil (used in manufacture of paints, varnishes, oils, inks, and linoleum), and approximately one million gallons of crude sulphate turpentine.

Power Department: More than six billion pounds of steam were generated in 1949; over 260 million kilowatt-hours were generated. The plant's power department makes enough electricity to supply a city the size of Savannah. More than 600,000 barrels of fuel oil were used during last year. Black liquor (spent cooking liquor containing materials dissolved from wood in cooking pulp) and bark from pulpwood are also used as fuel.

Bag Division: The bag division is divided into three departments: specialty, standard grocers, and multiwall. These three departments produce a total of approximately 35 million bags every day. These bags are of all shapes and sizes and serve many purposes. Bags run from $^1/_2$-pound size to 100-pound multiwall bags for packaging heavy materials such as fertilizer, feeds, building materials, etc. Paste used in bag manufacturing costs approximately $350,000 per year and the ink used in printing the bags costs approximately $300,000 per year. Bag division operates 24 hours a day, 5 days a week.

Box Factory: This is plant's newest converting unit. Here are manufactured corrugated shipping containers for many of the nation's largest business concerns. Production capacity of box plant is 6000 tons of corrugated board a month. Some of the corrugated board manufactured in Savannah is shipped to Union Bag's box plants at Trenton, N. J., and Chicago, Ill. Box factory operates 24 hours a day, 5 days a week.

Plant Personnel: Plant, including offices, employs approximately 4200 people whose total annual wages and salaries last year were over 11 million dollars. Work week for plant and office employees is 40 hours. Plant employees are unionized. The number of persons employed in each division is: Pulp & Paper, 1570; Bag, 1760; Box, 275; Industrial Relations, 80; Accounting, 220; Technical, 250; Woodlands, 100. All employees are covered under pension or retirement plan with company paying most of cost. Employees have in force more than 24 million dollars in life insurance under company-sponsored group purchase plan. Tremendous emphasis is put on safe working conditions. In 1949 only one lost-time accident occurred for every 88,881 man-hours worked.

Operating Expense: Besides wages, salaries, and wood costs, plant spends per year approximately three million dollars for chemicals and repair materials, and annual freight bill amounts to eight million dollars. In 1949, traffic department handled 51,254 inbound and outbound freight cars which would equal a train 440 miles long. Plant's products are shipped to every state in the Union and to many foreign countries.

Miscellaneous: Approximately 4000 people are shown through the plant each year. Some 10,000 pieces of material including booklets, pictures, etc., all pertaining to the plant's operations, were mailed to schools, civic groups, etc., during the past year.

TAPPI Standards Corrections

In T 205 m-50 the Robert Mitchell Co., Ltd., has moved to 64 Decarie Blvd., St. Laurent, Montreal 9, Que.

The Paper Makers Assoc. of Great Britain & Ireland (Inc.) has changed its name to the British Paper and Board Makers Assoc. (Inc.).

In the upper right-hand corner of Sheet 4, reference is made to a Lempen mill. It should be Lampen mill.

In Literature Reference 3, the author is C. Alexander.

In T 227 m-50 the correct address of Testing Machines, Inc., is 123 W. 64th St., New York, N. Y., instead of 427 W. 42nd St. as given in the footnote.

LETTERS TO THE EDITOR

Editorial Achievement

To the Editor, *Tappi:*

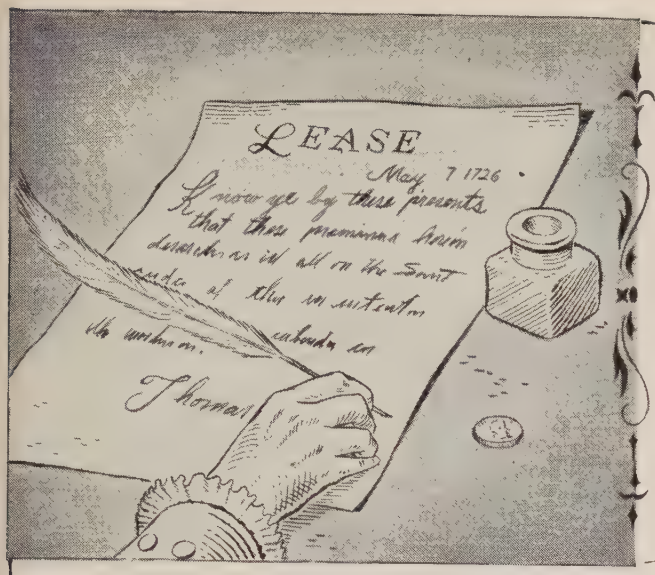
Permit me to extend to you my sincere congratulations on the award you received for *Tappi*, being the 1951 First Prize Plaque for Editorial Achievement. I think that this is a remarkable record when you consider the time you have been getting out this publication. It usually takes a long period of time before anyone can ever achieve this distinction but, I think that you have been able to blossom out with a mighty fine magazine right off the bat, which is not the customary procedure.

D. C. Everest, *Chairman of the Board*
Marathon Corp., Rothschild, Wis.

To the Editor, *Tappi:*

We wish to congratulate both you and *Tappi* for doing such a swell job that you received the Editorial Achievement Plaque of Industrial Marketing commemorating your good work. We know that it must have afforded the folks who work on *Tappi* a great deal of satisfaction to have your efforts so recognized. I am sure that all of the members of TAPPI feel that the award you received was well merited. That goes for me too.

Wm. Schoenberg, *Secretary*
Lake Erie Section, Cleveland, Ohio



*A shilling a year!**

**Being one of a series of monographs demonstrating the ingenuity of paper makers of yesteryear.*

ONE Shilling a year! That was the consideration on the land rent agreement signed by Thomas Willcox in 1726, prior to the building of his early Pennsylvania paper mill, a few miles southwest of Philadelphia.

The first output of the Willcox mill is said to have been fullers' press board. Later, printing paper was made for Benjamin Franklin. Still later the owners of this mill circumvented shortages of various sorts by specializing in the manufacture of banknote paper. At the time of the Revolution, government authorities depended entirely on this mill for paper for currency purposes, and placed implicit confidence in the honor of the Willcox mill.

Shortages and other difficulties seem always to have been unwanted guests of paper manufacturers. Theirs has always been a constant struggle to improve the utilization of men, materials and machinery, to meet an ever-increasing demand for paper.

Pennsalt research chemists eagerly welcome the opportunity to help manufacturers boost production and lower costs. Specific inquiries are invited. *In the East:* Pennsylvania Salt Manufacturing Company, Philadelphia 7, Pa. *In the West:* Pennsylvania Salt Manufacturing Company of Washington, Tacoma, Washington.

PENNSALT PRODUCTS: Liquid Chlorine • Caustic Soda • Anhydrous Ammonia • Bleaching Powder • Perchloron® • Hydrogen Peroxide • Sodium Arsenite • Sodium Chlorate • Sodium Hypochlorite • Forest Insecticide Sprays.

PENNSALT DISTRICT OFFICES: Philadelphia • Tacoma, Wash. • Portland, Ore. • Appleton, Wis. • Berkeley and Los Angeles, Calif. • Chicago • Cincinnati • Wyandotte, Mich. • Paterson, N. J. • Pittsburgh.

PENNSALT CHEMICALS
for Industry • Agriculture • Health • Home

PROGRESSIVE CHEMISTRY FOR OVER A CENTURY

TAPPI DIVISIONS AND COMMITTEES

Recent Reports of Activities

Wet Strength Committee

The Wet Strength Committee has started the preparation of a monograph on Wet Strength Paper. The following proposed outline of its contents has been approved by the committee. It is expected that a rough draft of the publication will be ready for the TAPPI annual meeting in February. Individuals who are acquainted with this subject are urged to study the outline and send suggestions to Kenneth W. Britt, Chairman of the TAPPI Wet Strength Committee, Scott Paper Co., Chester, Pa.

Part I—Introduction

A. Definition of wet strength paper.
   From TAPPI Standard T 456 m49 with amplified discussion of papers which are difficult to wet and the uses of liquids other than water for wetting.
B. Uses of wet strength paper.
   1. Historical, including uses in World War II.
   2. Present and prospective uses.
      List the more important uses with estimate of relative importance. For example: bags, frozen food wrapper, food wrappers in general, towels, tissue, map, saturating photographic, blueprint, currency, lithographic, etc.
C. Materials and processes:

Parchment	Melamine-formaldehyde
Viscose	Phenol-formaldehyde
Formaldehyde	Amberlite W1
Glue-formaldehyde	Locust bean gum
Urea-formaldehyde	Quar
Polyethylenimine	Neoprene

D. Effect of wet strength treatments upon other sheet properties.
   1. Dry tensile and dry mullen increase.
   2. Increased fold.
   3. Improved wet and dry rub resistance.
   4. Reduction of dusting and linting.
   5. Improved wax pick test.
   6. Improved sizing.
   7. Retention of other materials in the sheet.
   8. Dimensional stability.

Part II—Raw Materials

A. Description of materials most commonly used.
   1. Urea-formaldehyde resins.
      Structure, modification, degree of polymerization, stability.
   2. Melamine-formaldehyde resins.
      Structure, degree of polymerization, preparation of colloid, stability in solution.
B. Technical control for quality of resins.
   Viscosity, miscibility, pH, laboratory handsheets.
C. Instructions for shipment and storage.
D. Statistics on production and cost.
E. Equipment for storage and handling of resins. Equipment for manufacturing resins.

Part III—Operating Procedures for the Manufacture of Wet Strength Papers

A. Methods of application.
   1. Beater addition (any point prior to wire).
   2. Tub treatment.
   3. Spray application.
   4. Off machine processes.
B. Equipment at the paper machine.
   1. Batch process.
   2. Continuous addition of resin solution. Rotameters, proportioning pumps, etc.
   3. Methods and equipment for pH control.
C. Corrosion problems on the machine.
D. Water reuse.
E. Cleaning of stock systems, wires, felts, press rolls, and driers.
F. Broke recovery.
   1. Wet strength material determines the recovery methods.
   2. Recovery conditions for UF and MF broke. Ph temperatures.
   3. Mechanical equipment:
      Steam jet equipped beater.
      Hydropulper.
      Broke beaters.
      Pressure cookers.
      Soaking pits.
   4. Waste paper.

Part IV—Chemistry of Wet Strength

A. What causes wet strength—mechanism—theory of interfiber bonding in wet strength and non-wet strength papers.
B. Retention of wet strength agent.
   1. Charge on resin particles.
   2. Role of salts, anions and cations, alum.
   3. Effect of fiber area.
   4. Behavior of various pulps.
   5. Particle size of wet strength resins.
   6. Retention vs. wet strength.
C. Curing of wet strength resins.
   1. Temperature.
   2. Time.
   3. pH.
   4. Other factors.
D. Permanence of wet strength papers.
   1. Relative permanence of materials and processes.
   2. Effect of temperature, humidity, and pH.
   3. Effect of MF and UF on usual permanency tests.
   4. Methods of evaluating permanency.

Part V—Process Control

A. Preparation of solutions for use on the machine.
B. Checking quality of solution ready for use.
C. Factors affecting wet strength development.
D. Point of addition—effect of time, consistency, mixing, subsequent refining.
E. White water reuse. Function of fines.
F. Effect of furnish.
G. Maintenance of equipment.
H. Records—resin consumption per ton, resin efficiency.
I. Trouble shooting.

Part VI—Testing Procedures and Methods of Reporting

1. Strength tests—tensile, mullen.
2. Nitrogen analysis.
3. Prediction of cure. Quick cure.
4. Identification of urea and melamine in paper.
5. Dye staining techniques.
6. Formaldehyde determination.
7. Wet rub tests.
8. pH of paper.
9. Determination of whether sample of resin is anionic or cationic.
10. Utility tests.
11. Hydrolysis of wet strength paper.

Part VII—Market Evaluation of Wet Strength Products

A. Estimate of present market of wet strength products.
B. Examples of improved usefulness of paper products by the use of wet strength.
   1. Result of consumer survey studies.
C. Economics due to wet strength.
   1. Reduction in basis weight.
   2. Reduction in area of paper required.
D. Paper products made possible only by wet strength.
E. Techniques in demonstrating and selling wet strength products.

Part VIII—Bibliography and Index

A new bibliography which adequately documents the text.

Insecticide-dusting the modern way.

INSECTICIDES...

one of many uses for CHLORINE

Chlorine is an essential component of many insecticides and weed killers. But it is also in heavy demand for other important uses. To its direct applications as a bleach and as a sanitizing agent are added its constantly expanding use in the manufacture of pharmaceuticals — anti-freeze — chlorinated hydrocarbons for solvents and refrigerants — synthetic glycerine — chlorinated styrene and polyvinyl chlorides for plastics and rubber.

Matching chlorine production with demand is particularly difficult in times like these. Mathieson is increasing its production facilities to provide this basic chemical and many of its derivatives on a broad scale. Consult Mathieson — possibly a program to meet your future needs can be arranged. Mathieson Chemical Corporation, Mathieson Building, Baltimore 3, Maryland.

Mathieson
CHEMICALS

SERVING INDUSTRY, AGRICULTURE AND PUBLIC HEALTH

It is not the purpose of this bibliography to list every reference in the field, but merely to list those which are pertinent to the text.

Structural Fibrous Materials Committee

The efforts of the Structural Fibrous Materials Committee, since the February meeting, have been devoted primarily to reorganization and the setting in motion of the reorganized groups. However, progress has been made particularly in Subcommittee No. 4, "Drainage Time Testing," where agreement was obtained on construction details for two Drainage Time Testers and construction begun. Subcommittee No. 3, "Test Board Formation," has submitted a Suggested Procedure for Test Board Formation and an application for a Research Appropriation prepared.

Subcommittee No. 2 obtained, edited, and submitted three papers prepared and delivered for the last February meeting.

Subcommittee No. 5, "Transverse and Deflection Testing," agreed upon a testing method in principle but recognized one serious, controversial point, i.e., speed of testing. A program was agreed upon for outside testing to establish the point in question and an application for a Research Appropriation prepared.

Subcommittee No. 6, "Water Absorption, Water Penetration, and Water Vapor Permeability," has begun a review of the three tests and selected Water Vapor Permeability as a likely starting point for their work.

Subcommittee No. 7, "Nail Holding and Racking Test," has decided upon a program involving outside testing work and has prepared a request for approval for a Research Appropriation.

Subcommittee No. 8, "Light Reflection Measurement," has reviewed a number of tests and recommendations of other groups interested in the problem. It may be possible to settle on a method this year.

There has been some discussion of a Fall meeting but it was decided to pass that for this year in view of the newness of the reorganization and additional effort needed to stimulate proper functioning this year. We are under way in a creaky fashion at present but definitely moving. Our first bimonthly report included reports from chairmen of all but one of the action subcommittees.

There is a need in the Structural Fibrous Materials Committee for a small three- or four-man Steering Subcommittee, the Committee being quite large and the subcommittees numerous. I have plans for a Steering Subcommittee in preparation at this time. In addition to the proposed Steering Subcommittee there seems to be room for one more action subcommittee. Subcommittee No. 1, "New Projects and Reviews," is at present considering a suitable subject for such a new subcommittee.

I have particularly noted since joining the Structural Fibrous Materials Committee that committee activities have been confined entirely to softboard. There are two other types of board that it would seem to me should also be included in the Committee's work, i.e., hardboard and resin-bonded, fibrous boards. Probably the extensive work, necessary and urgent in softboard, has in the past attracted the full attention of the Committee to that product for the time being. It is planned to bring up this question of other types of structural fibrous materials when the new Steering Subcommittee is organized and I would appreciate Mr. Kaufmann's and your comments before carrying the matter much further.

Subcommittee No. 2, "Papers, Publications, and Review," has begun work on a program for the next February meeting (later the program will go to the Steering Subcommittee). The Subcommittee has not progressed very far as yet but it appears the Structural Fibrous Materials Committee should sponsor a program centered around one or two subjects, raw materials testing, and/or stock preparation and control. The plan would be to present one, two, or more short papers on the subject, then develop a discussion headed by a panel to answer and stimulate questions. The whole program to cover $2^1/_2$ hours approximately.

In addition there should be separate meetings of the various eight or nine subcommittees followed by a joint meeting of all subcommittees. The plan would be to hold the individual subcommittee meetings one day and a joint meeting on a following day at which time the main committee chairman and secretary would have a condensed report of all subcommittee activities and progress.

Following the two subcommittee meetings the Structural Fibrous Materials Committee itself would have a meeting to review briefly the Committee's business and plan for the coming year.

EDWARD M. JENKINS, *Chairman*
Johns-Manville Research Center
Manville, N. J.

Statistics Committee

The Statistics Committee met on June 8, 1951 at the Griswold Hotel, Groton, Conn. Those present were: Geoffrey Broughton, Lowell Textile Institute; Geoffrey Beall, Univ. of Connecticut; Maynard S. Renner, Dewey and Almy Co.; Richard Bingham, TAPPI; Harold W. Cobb, Secretary, *pro-tem*, S. D. Warren Co., and John F. Langmaid, Jr., Chairman, S. D. Warren Co.

The following program was adopted and action taken as indicated.

(1) Preparation of a Manual of Statistical Applications to the Pulp and Paper Industry: A subcommittee was set up with Dr. Geoffrey Broughton as Chairman. Dr. Broughton is to pick his own committee members. To facilitate the work of the Committee the members will be geographically close together.

The general purpose of the manual is to show where and how statistical methods can be used in pulp and papermaking operations. The manual should not be a treatise on statistics with examples applicable to pulp and paper, but rather a discourse on pulp and paper operations showing where and how statistical methods can be used. For greatest interest the first articles written should deal with problems common to most paper mills, such as paper machine operations, and work from this central problem backward and forward to problems of less universal occurrence.

As the various articles making up the manual are completed it is hoped they will be published in *Tappi*. When completed it is proposed that the manual be published and distributed to the membership.

(2) Data sheets—Nomograms and Graphical Aids to Statistical Calculations: This work is to be incorporated with (1).

(3) Short Conference on Quality Control for Paper Industry: A subcommittee with Geoffrey Beall as Chairman was set up to organize such a course. Dr. Beall will pick his own committee members. The University of Maine is interested in putting on such a course during the Summer of 1952. John Calkin, Director of Dept. of Industrial Cooperation, U. of M., will be consulted.

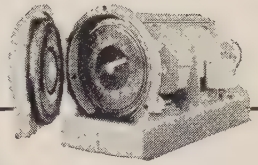
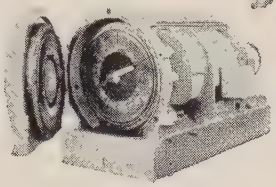
Lowell Textile Institute is interested in a Saturday series, for technical people in general, in the Boston area. Dr. Beall will contact Albert Davis, Director of Extension Service, Rochester Institute of Technology, for advice on such a course. It was suggested that the word "Conference" rather than "course" be used.

As financial aid (through the Research Appropriation Committee) may be required to get such a program started, it was decided that any plan for a conference on quality control should be sponsored by the Statistics Committee

to solve SEMI-CHEMICAL refining problems economically –

a large South-Eastern Mill uses

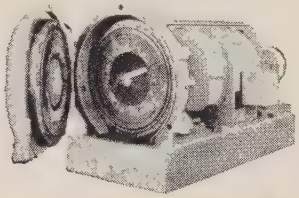
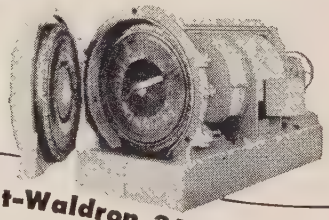
Sprout-Waldron Refiners

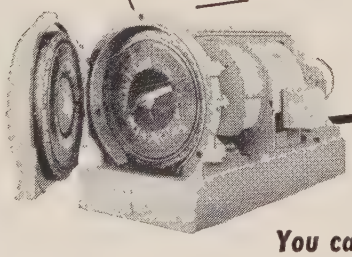
One of the largest integrated pulp-to-container plants in the world is now building a 300 ton per day semi-chemical pulp mill, expandable to 400 tons to make .009 corrugating board for its own use. 9 Sprout-Waldron Refiners will do the pulping.

Here's why S-W Refiners are preferred by mills throughout the United States and Canada:

- Flexibility of operation
- High capacity
- High pulp quality
- Ease of feeding
- Low capital investment
- Low maintenance costs
- Low plate costs per ton of pulp

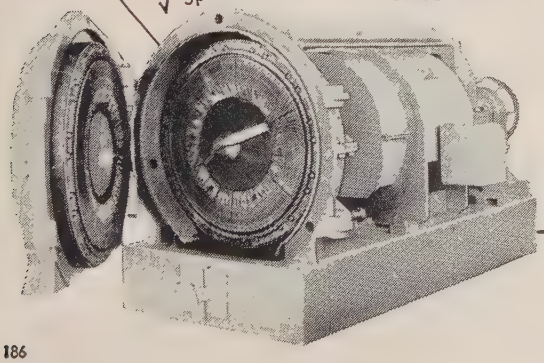
The Sprout-Waldron 36-2 Refiner is THE SEMI-CHEMICAL PULP REFINER
It's the top producer of semi-chemical pulp today



List of Applications

- √ Semi-chemical Pulping (Bleached-Unbleached)
- √ Pre-Refining—High Yield hot brown stock
- √ Kraft—Groundwood—Sulphite Knots & Screenings
- √ Secondary Refining of Asplund Stock
- √ Bleached Soda Pulp
- √ Insulation Board Stock
- √ Hardboard Stock
- √ Flooring Felt
- √ Special Applications

SW SPROUT WALDRON SINCE 1866



You can pinpoint exact pulp test requirements with the Sprout-Waldron Refiner.

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and not the University at which it is held. Any institutions interested would be asked to supply the physical space required and help from their teaching staff. If successful, the Statistics Committee would plan to hold the Conference at a different location each year so as to make it available to as many members of the industry as possible.

(4) Finishing Room Sampling Plans: This is a complex problem and the Committee felt that the work should be done by an outside agency financed, if necessary, by a grant from TAPPI.

(5) Development of Simple Calculating Machine for Computing Standard Deviation: Many mills keep records of the average values of test results on orders manufactured. It would also be desirable to have a record of the variability of the values making up the average. Standard deviation, if easily calculable, would be the most desirable statistic to show this. Clerical work involved should be no greater than required in computing an average with an ordinary adding machine.

(6) Mr. Richard T. Trelfa will be asked to compile a list for publication of bibliographies and speeches on quality control.

(7) Book Reviews: Continue to have book reviews published in *Tappi*.

(8) Continue General "Missionary" Work: General effort will be made to interest Local Sections in giving statistics a place in their programs.

Fourdrinier Papermaking Committee

The Fourdrinier Committee has been in existence for quite some time, but it has only been in the last two years that a few of us who are interested in smoking out the basic principles underlying fourdrinier operation have been able to get much accomplished. At the 1950 Annual Meeting the Committee sponsored a symposium on "Slices" that was very well received, and we extended it into the 1951 meeting. During the past convention we also inaugurated the "closed" meeting idea by inviting representatives from mills to discuss one subject, and had a most interesting and informative meeting on the subject of "Paper Defects—Cause and Cure."

For the year 1951–52, the Fourdrinier Committee has established the following subcommittees:

Tissue Subcommittee—Larry Thompson, Personal Products Corp., Chairman.
Book, Bond, and Specialists Subcommittee—F. L. Zellers, Chillicothe Paper Co., Chairman.
Kraft and Fourdrinier Board Subcommittee—Chairman to be appointed.

For the 1952 meeting, we plan to have invitation meetings to cover the following subjects:

Tissue Machine Operation.
Importance or Unimportance of Shake.
Paper Defects—Cause and Cure.
Surface Sizing.

The subject matter is sufficiently diversified so that we will be able to have a representative from every mill that operates fourdrinier machines at the meeting that interests his mill. Not all mills will be interested in each of the above subjects. The discussion will be based on questionnaires that will be circulated among the various mills.

Paper Defects Round-Table Meeting (Feb. 20, 1951)

To intelligently discuss the problems of paper defects, the Committee approached the question by first defining paper defects as related to fourdrinier machine operation.

Many definitions were offered and the more appropriate are listed below:

1. "Paper defects are localized flaws that may be seen or felt or become apparent in subsequent converting operations."
2. "Paper defects are imperfections that mar the sheet of paper for the convertor or ultimate consumer."
3. "Paper defects are those localized conditions which may or may not interfere with subsequent use of the sheet of paper."

In an effort to clarify the many and various defects found in fourdrinier operation, it was felt by the discussion group that the defects might be broken down into two or more groups. One suggestion was to divide the imperfections into visible and invisible defects. The visible defects would include those which are readily apparent to the paper machine help and the invisible would be those not seen by the machine help but prove to be a hindrance to the paper printer or convertor such as poor ink pickup. Paper convertors find that curl, thickness variations, poor roll preparation, and poor adhesive absorption are the more prevalent sheet defects.

Another method of defining the defects of a sheet of paper would be to arrange them according to mechanical and inherent characteristics. The mechanical defects would include such imperfections as off-weight, scale, holes, and wrinkles. In the category of inherent defects would fall curl, grainy edges, and "galvanizing." Inherent defects, therefore, would be of a structural nature and difficult to correct in the normal operation of the paper machine.

By listing all the possible defects which may be attributed to wet-end of a fourdrinier paper machine, the discussion group felt that a clearer picture of the causes and cures might be obtained. The list includes in some cases, no doubt, a certain amount of duplication due to the colloquialisms used to describe certain of the defects. In addition some of the imperfections are accompanied by the apparent source of trouble and the remedial action necessary to correct them.

I. Paper Defects That May Be Attributed to or Become Apparent on the Fourdrinier Section of a Paper Machine

A. *Mechanical Defects* (More or less controllable by the machine men).
   1. Off-weight.
   2. Uneven thickness or caliper across the sheet.
   3. Stock lumps and slugs.
      Source: Screens, pumps, deckle straps, slices, dead spots in headbox, jordans, perforated distributing roll—too small clearance or stopped.
   4. Slime spots and slime holes.
   5. Scale.
   6. Thin streaks caused by a ridged wire.
   7. Lumps or distorted surface caused by carrying roll not being clean.
   8. Suction couch roll skips.
   9. Pickups by top couch roll.
   10. Foam.
   11. Water spots.
   12. Bubbles.
   13. Wire impressions.
      Source:
      (a) Holes from wire holes.
      (b) Marks from wire patches.
      (c) Wire seam marks.
      (d) Improper wire mesh for grade of paper.

B. *Inherent and Structural Defects* (Due to the nature of the fourdrinier machine).
   1. Poor formation.
      (a) "Open."
      (b) "Cloudy."
      (c) "Wormy."
      (d) "Pinniness."
      (e) "Crushy."
   2. Two-sidedness.
   3. "Galvanizing" or "Marbling."
   4. Apron streaks.
   5. Dandy lumps, licks, and crush marks.
      Source: Dirty dandy roll cover, too much water on the dandy shower, too much (also can be too little) water in sheet going under dandy roll.
   6. Grainy edges.
   7. Cockles.
   8. Surface fuzz.
   9. Longitudinal streaky formation due to localized cold water from showers. This may be corrected by better water sprays.
   10. Streaks across sheet due to table roll being out of round.

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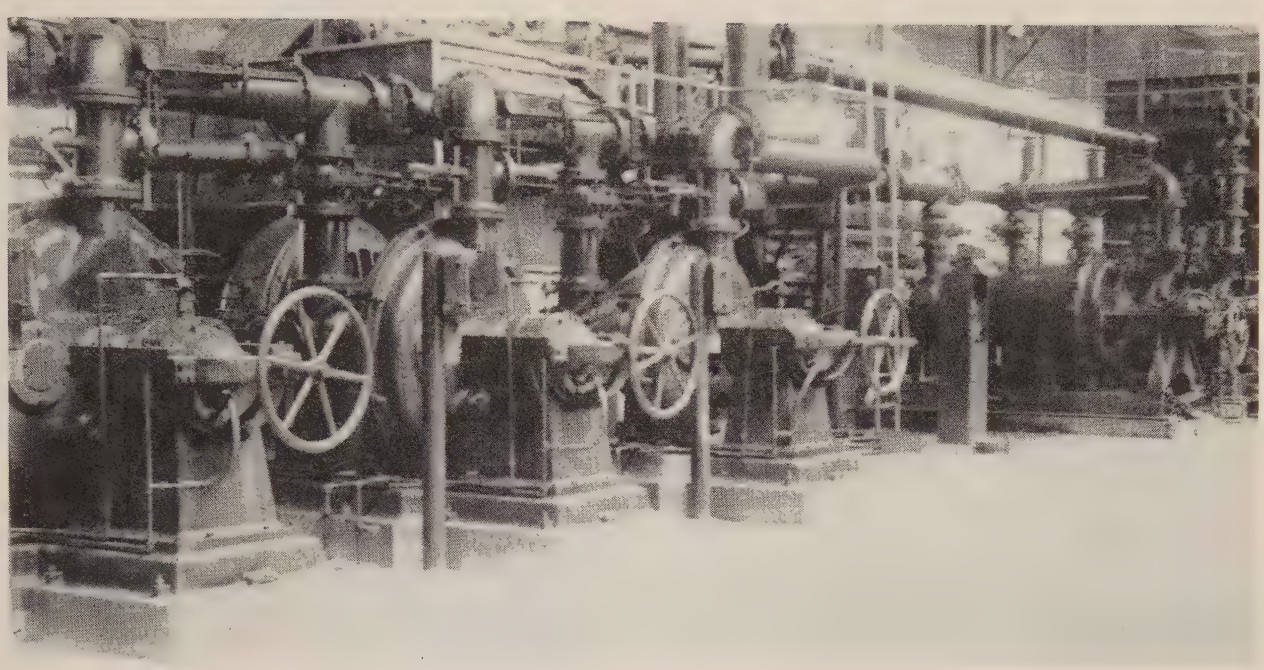

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11. Flow streaks or wash marks.
12. Lumps similar to heavy froth due to slice being a little downstream from apron board.
13. Poor or unbalanced directional strength which may or may not be a defect depending upon grade of paper being made.
14. A factor in the over-all picture of "curl" in paper.

II. Paper Defects Attributed to Wet Press Section

1. Crush marks: (a) general; (b) streak or spot due to felt being filled.
2. Blanket marks caused by too large amount of nap being worn away.
3. Blow marks.
4. Localized crush marks resulting from the felt condition.
5. Water drops.
6. Streaks or marks caused by damaged press roll surfaces.
7. Shadow marks resulting from suction presses.
8. Mark from tight draw from wire to first press (across sheet).
9. Mark due to seam of felts being crooked and closing up weave of felt—crushed mark.
10. Leaky press doctor—dull or deeper colored streak.
11. Draw wrinkles.

From the list of defects brought before the closed meeting, the time available for discussion limited the contemplation of only two of these defects. The first imperfection dealt with was "marbling" or galvanizing." It was described as a visual defect of the wire side of a sheet of paper characterized by small bundles of apparently oriented fibers having the appearance of the surface of galvanized iron. There is no period regularity in the appearance of this defect. The phenomenon brings about minute differences in the thickness of the sheet that are too small to detect with the normal paper testing micrometer. Many men of the group believe that "galvanizing" is brought about by the property of the stock to clot or flocculate. The trouble has become more pronounced with the use of high head slices and increased machine speeds. Long aprons also contribute to "galvanizing." Undoubtedly, hydraulic flow behind the slice is a factor in this phenomenon. Wire side streaks with a definite periodicity are apron streaks, usually caused by fibers adhering to the apron lip.

To eliminate the problem, the use of a "holy" or perforated distributing roll was recommended. The adjustment of the top slice lip and apron lip in relation to the center line of the breast roll was given as a satisfactory remedy. However, in at least one instance, this brought about an increase in the tendency for the sheet to curl.

"Shadow-marking" by suction press rolls was the second defect considered by the meeting. The tendency to mark appears to be greater with slow stock and more pronounced with old rather than new felts. "Shadow-marking" is also brought about by the gradual "cupping" or countersinking of the holes in the rubber covering of the suction roll. It may be eliminated by grinding to the bottom of the "cups" plus 15 thousandths of an inch. The use of a rubber covering with a plastometer reading of 35–40 will tend to reduce marking, it was remarked.

Considering the interest demonstrated on the subject of "Paper Defects—Cause and Cure," another discussion meeting will be held in the future in an effort to expand the knowledge of the papermaker so that a scientific foundation may be laid, resulting in the improvement of paper quality amid more efficient machine operation.

Noel R. Phillips, *Chairman*
Robert G. Hitchings, *Secretary*
Fourdrinier Papermaking Committee

Electrical Engineering Committee

Electric Cable Subcommittee

The Electric Cable Subcommittee of the Electrical Engineering Committee held its first meeting in the Conference Room of the St. Regis Paper Co., Cantonment, Fla., on May 11, 1951. Those present were: A. O. Mortenson, St. Regis Paper Co., Chairman; Shelby Cooke, General Electric Co.; John Hogan, Okonite Co.; A. O. Smith, Merritt-Chapman & Scott, and Larry Clapp, St. Regis Paper Co.

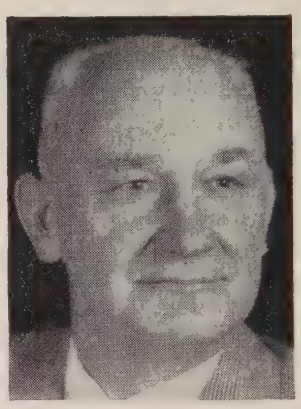
The meeting was devoted to a consideration of TAPPI Project No. 369, "Application of Electric Cable in the Paper Industry." The TAPPI Subcommittee is working jointly with a committee of the Insulated Power Cable Engineers Association composed of the following individuals:

E. W. Davis, Simplex Wire & Cable Co., Cambridge, Mass.
R. C. Graham, Rome Cable Co., Rome, N. Y.
M. H. McGrath, General Cable Co., Perth Amboy, N. Y.
S. J. Rosch, Anaconda Wire & Cable Co., Hastings-on-Hudson, N. Y.
G. W. Zink, Haverstraw Cable & Wire Div., Phelps-Dodge Copper Products Corp., Yonkers, N. Y.
R. G. Sturdevant, United States Rubber Co., Bristol, R. I.

The two committees met again at Cantonment, Fla., on July 27. A report of the proceedings will appear later in *Tappi*.

Following are the minutes of the May 11 meeting:

Mr. Mortenson: At the outset I think it would be no more than fitting for me as chairman of the Subcommittee, to welcome you fellows—not only those who appear at this table but those who are here in spirit as well. There are two to welcome who were not able to make their appearance here today—one, the Simplex Wire & Cable Co., who through their Mr. Davis the day before yesterday advised by telephone that they would give us all the assistance they could. Sorry they could not attend this meeting. They had a prior engagement with IPCEA. The second one is the Rome Cable Corp. of Rome, N. Y. E. Mark Wolf wrote us and said that he, too, would be kept away from the meeting but that he wanted minutes of the meeting and the results of what transpired. He will give us his assistance. Rome has shown real interest. We feel that they will come through with much that will be of value. So much for the welcome. Now perhaps it would not be amiss to refer briefly to the stand taken by Mr. Del Mar. It shocked me, really, when I read the first paragraph of his letter. I think he sent a copy to everybody here and all the others marked for a copy of the original notice and invitation that went out April 9, 1951. My copy did not arrive until long after you gentlemen received yours due to the fact that it was sent to St. Regis, New York, instead of Pensacola. Might say that the good gentleman was off base in his contention that we were attempting to enter the field of specifying insulations that would spell the creation of new products. We aim to do nothing other than to recommend to our parent organization, TAPPI specifications from what is in the field today that will serve best in all departments of the industry, taking in ground wood, sulphite, sulphate, waste paper, rags, etc. So later when one sets out on a plan of improvement he can use the standards set up by TAPPI with assurance that he is specifying the best that the market affords for every service contemplated. That's everything we aim to do.



A. O. Mortenson, St. Regis Paper Co., Cantonment, Fla.; Chairman, TAPPI Cable Subcommittee in the Electrical Engineering Committee

We followed Mr. Del Mar's excellent suggestion that we invite IPCEA to participate and send their Secretary, G. M.

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Haskell, an invitation to take part in this meeting. We have received response through Mr. Davis that they would cooperate with us and he is to write us as to how best to go about getting cooperation from IPCEA.

I will read Mr. Davis' letter of April 23. (Reads.) Mr. Davis' suggestion that we get the Insulated Power Cable Engineers Association to form a joint committee and string along with us is well taken, and we will invite them to do that very thing just as soon as we can get to it. We need and welcome all the help we can get. So, certainly we will be glad to get assistance from this very able source.

Knowledge of G. J. Crowdes' confinement to the hospital through illness brings regret from this Committee. We hope that he will quickly recover from his illness.

Well, gentlemen, through the courtesy of our Technical Director, Larry Clapp and O. A. Smith of Merritt-Chapman & Scott we have something here that I think will serve as a basis for our deliberations and a means of setting something up that we can add to later. Here is a plan of our spread—this factory we are in, entitled "General Plan Typical Sulphate Pulp and Paper Mill." Mr. Clapp has given us here the chemicals and conditions encountered in a typical southern sulphate pulp and paper mill using the nomenclature as set up here. On the back page are compositions of the various liquors and solutions that are to be encountered in the various departments. Now, with this before us, perhaps it would be smart for me to introduce into the record the suggestions of Mr. Cooke of G.E. and Mr. Smith of MC & S on how best to go about what we are undertaking.

(Mr. Mortenson reads Cooke's suggestions contained in his letter of April 18.)

Now Mr. Clapp has given us conditions to be found in just about every mill in the South aside from two, Lufkin and Coosa River. This, however, is typical of 50 or 60 mills here in the South. We here in Pensacola will follow through and circularize the entire industry to get as clear a picture as is possible, borne of experience, concerning what is best to use where.

(Reads Cooke's letter again, fourth paragraph, in which he says we are to "determine which cables presently being manufactured by the cable industry are most suitable and applicable to the various types of operations found in the pulp and paper industry."

That's it, fellows. Can't quite understand how Mr. Cooke and Smitty hit it so closely. Mr. Smith says about the same thing Shelby does, only in different words and gives more of an outline in steps, step by step. Now, Mr. Smith's letter says this. (Reads letter of April 24.)

With all this related matter before us we really have a working manual, and I suggest we go to work. With that, gentlemen, I am going to ask for suggestions now as to how we should go about working out a plan of procedure from here on.

Mr. Hogan: The system volts, distribution from generating plants to substations and to large size motors and branches that break down to 440 and lower voltages for small motors and other purposes would give us a start. From the point of view of cable manufacturers there are two principal types of cable: (1) rubber-insulated neoprene cable; (2) paper-leaded cable for certain voltages ranging to 15,000. 66 and 6900 and 13,800 go in the 15,000-volt class. Both types would go okay up to 15,000 and it is really a choice by the user that has been determining what has been used.

Mr. Smith: Would that apply to 5 kv.? There are quite a few plants here in the South that use that voltage.

Mr. Hogan: In that case the industry standards say that the 5000-volt class will do. Ordinary range of voltage, however, is 2000 to 4000 for this class of insulation. As you get down to lower voltage one type of cable will generally do for all purposes.

Mr. Smith: About 4160 distribution—would you go to 5-kv. cable?

Mr. Hogan: If you were to manufacture 4160-volt cable, in all probability you would go to a cable with 0.1064-inch rubber insulation. Now right at the minute there is controversy among cable manufacturers with regard to shielded products. Conducting neoprene sheath is quite often used but the results haven't been too good. Nonconducting sheathed type now most generally recommended up to 3000 volts. Shielded cables are generally used for 4000-volt distribution and above.

Mr. Smith: What is the difference, which cable will or won't satisfy that condition? When specifications are written, as I must do often, we don't know enough about the capacity and then we receive a lot of quotations which we have to consider without regarding price. How are we to determine whether to use those shielded above 3000 or above 5000 or what? The paper industry would like to know.

Mr. Hogan: Probably most people would decide that on their operating experience. Not necessary to have shielded on 4000 volts from point of view of safety of production personnel. This choice would probably depend on what experience the individual operator has had with shielded or nonshielded. Another thing would influence choice—shielded is more costly than nonshielded.

Mr. Cooke: The standpoint of this Committee in making recommendations on cables lines up with IPCEA. We will not change any basis they might set up.

Mr. Hogan: Talking about rubber insulation, every cable manufacturer has a rubber insulation for 5000-volt ozone resisting. I think the decision on what grade should definitely be used should not be included in these specifications. On the basis of Cooke's suggestion strictly with IPCEA standards there would probably be two classes—4160 rubber-insulated shielded and 2300 volts rubber insulated without shielding. Up to 600 volts there is choice of all kinds of insulation—operating experience can be the guide for this. In the 600-volt field you find the widest difference of opinion. That's something determined almost entirely by operating conditions.

Mr. Mortenson: Take a look at this. Might prompt thoughts and questions. (Shows Mr. Clapp's chart.) Chip Preparation reads: "Outdoor conditions, lime dust, blow steam turpentine, alkaline fumes from recovery stacks, water." What would meet those conditions satisfactorily?

Mr. Hogan: A lot would depend upon what you wanted to make of your place. Some places try to make a park of their mill. Old mills use wood poles. One thing that probably would apply in general is the moisture-resistant type of wire.

Mr. Mortenson: How about steam and alkaline fumes?

Mr. Hogan: Steam, if you had just any ordinary rubber-insulated wire it would be destroyed or damaged. Neoprene-sheathed cable withstands heat well and may be the best bet.

Mr. Mortenson: That is in the 600-volt class?

Mr. Hogan: Yes, but you could use it up to 4000 volts, so both those cables would be rubber-insulated neoprene-sheathed. Outdoors you might want to use self-supporting aerial type cable. It is used where they don't want everything underground for landscape beautification. The same type of conductors can be used. The difference being in the supporting messenger, which can be: (1) copper weld; (2) stainless steel; (3) galvanized steel, and (4) only under extreme conditions galvanized steel messenger components covered with neoprene.

Mr. Mortenson: Is that type of cable manufactured by most people in the cable industry?

Mr. Hogan: Yes, it is.

Mr. Mortenson: What is the claim for it over conventional conduit?

Mr. Hogan: The installation cost would be lower than conduit.

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Mr. Cooke: And any faults are more easily located.

Mr. Smith: Is the capacity increased?

Mr. Hogan: Slightly.

Mr. Smith: Is it economical?

Mr. Hogan: Yes.

Mr. Mortenson: How is aerial cable generally installed and supported?

Mr. Hogan: On wooden poles 100–150 feet apart with a line of special hardware used to support or fasten the messenger.

Mr. Mortenson: How about indoor installations?

Mr. Hogan: The physical appearance would be against it for indoor installation. Then, too, some feel that there is some danger to personnel in using aerial cable indoors.

Mr. Mortenson: Can it readily be taped and spliced?

Mr. Hogan: Yes, but there are tricks in doing it.

Mr. Mortenson: In your judgment, how does the appearance of such installation compare with conduit?

Mr. Hogan: It does not have as good an appearance as underground conduit.

Mr. Mortenson: Assume the conduit is exposed, what then?

Mr. Hogan: The conduit would have a nicer appearance. You can see the spiral metal messenger on the aerial cable and of course it doesn't look as good as smooth conduit. Of course the messenger can be painted to improve appearance. But, if you wish to make the plant look like a park you would not want it in any case. Self-supporting aerial against conduit shows up poorly if you want to make a show place of your plant. But, if economy is wanted it might pay to investigate it for certain installations.

Mr. Smith: How about the lightning situation on aerial cable?

Mr. Hogan: Lightning arrestors at both ends. Throughout the life of the cable it is more or less similar to lead sheath. It must be grounded frequently. 500 or 1000-foot increments.

Mr. Cooke: The AIEE has an investigation committee looking into the lightning exposure question now.

Mr. Mortenson: We have not thought about trenchlay yet.

Mr. Hogan: It could be used, made with a moisture-resisting rubber insulation and a tough neoprene jacket. There is a disadvantage in buried systems, however. When you have cable trouble you have difficulty making the repair.

Mr. Mortenson: We have found that if the proper type of trenchlay is used, generally speaking, it is very trouble free. Until it is injured through something coming in contact with it, some mechanical object, it stays put for years and years; and I am wondering if some mention shouldn't be made of trenchlay.

Mr. Hogan: If it is subject to rotting, use neoprene jacket.

Mr. Cooke: That is normally found not to be too economical.

Mr. Smith: The aerial cable question again. Does the voltage troubles you get from it go to point it up as not being as reliable as a conduit installation?

Mr. Hogan: As far as voltage drop goes, it would be slightly less for a length of aerial than conduit.

Mr. Smith: As a result of a direct lightning stroke?

Mr. Hogan: Not a whole lot more. A conduit installation on the outside of a building is subject to the same lightning as the aerial cable is. Lightning can strike in both cases but it can be warded off. I think aerial and exposed conduit are equally reliable outdoors.

"A" Requirement:

1. Rubber insulation—oil or mineral base.
2. Thermal plastics—polyvinyl chloride.
3. Varnish cambric.
4. AVC—Asbestos.
5. AIA—Felted asbestos with asbestos braid—resistor wiring.

Mr. Mortenson: Shall we go on to "B," Wood Room? Conditions good—indoor conditions: No fumes, etc.

Mr. Hogan: A certain amount of moisture will always collect.

Mr. Mortenson: How about voltages employed on chippers, elevators, etc.?

Mr. Smith: 4160 or 440-voltage range.

Mr Cooke: What size motors?

Mr. Mortenson: Up to 350 or 400 hp.

Mr. Cooke: Several 2400 volts. One up and coming type of insulation is interlocked bronze armored cable or aluminum.

Mr. Mortenson: Would it be safe for this Committee to recommend that type of armor to the pulp and paper industry?

Mr. Cooke: Yes, bronze. Thermal plastic sheath jacket could be put on over the armor if conditions are corrosive to bronze.

Mr. Smith: Keeping in mind this type of cable there are requirements that can perhaps best be met by neoprene sheath rubber insulation and conduit.

Mr. Hogan: Yes. Two alternatives in this "B."

Mr. Mortenson: Now we come to a real tough one, Digester Room. Conditions are pretty bad—outdoor with steam, white liquor, black liquor, water.

Mr. Hogan: Most cables would withstand those conditions. Similar types of cable are used in safer places. Route and locate so as to avoid exposure.

Mr. Mortenson: We'll continue with the Digester Room.

Mr. Smith: Actually not too much cable is used there other than for lighting.

Mr. Mortenson: Automatic blow valves, fans, and a few small motors.

Mr. Hogan: I think how these requirements will apply to the National Electrical Code is important and should be considered.

Mr. Mortenson: I have been in our industry in all parts of the country from northern Canada down to this southern section and wherever I have been I have been pretty free so far as the National Electric Code is concerned. There may be certain sections where the Code does apply, even though I haven't bumped into them. Mr. Smith may have had experience where the Code is enforced.

Mr. Smith: Yes, in Jacksonville. They were very strict.

Mr. Mortenson: Well, we will have to be careful.

Mr. Cooke: In most cases the larger organizations do not have to bother much with the Code.

Mr. Clapp: Back to the Wood Room about the bronze armored cable mentioned this morning, I am not too sure about it around the pulp mill. The sulphate fumes coming from the recovery stacks and the direct contact with sulphate dust might damage the bronze armor no end. It would have to be painted or coated in some way for protection.

Mr. Mortenson: Would you say then that we should eliminate bronze?

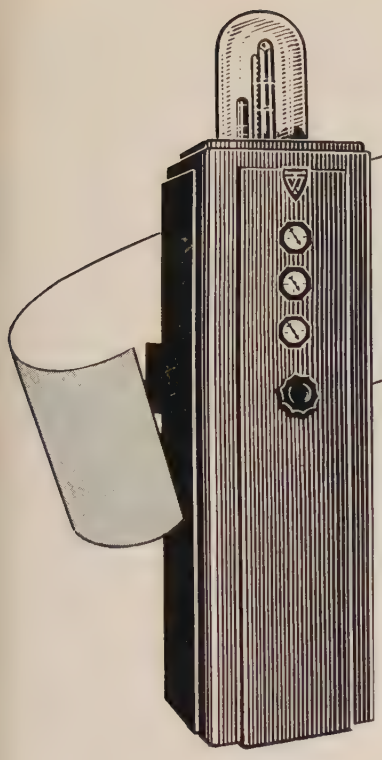
Mr. Clapp: How about galvanized iron armor?

Mr. Cooke: I don't know how practical it would be to coat armor of any sort.

Mr. Mortenson: Well, we will let that stand as is for now. We will come back to it later and get an answer. We were at the Digester Room when we left for lunch. As Smitty said there is not too much there to contend with—lights, a few small motors, and that's just about it. Is it the consensus that what holds for "A" would also hold for "C," incased in conduit?

Mr. Hogan: Yes.

Mr. Mortenson: Now we come to "D" and that's the Brown Stock Wash Room, outdoor conditions, steam, black liquor, hot water. There we have bad conditions and quite a number of lines.



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1-39

Mr. Smith: Small motors, lots of them, 600-volt classification.

Mr. Hogan: I think your choice is limited to two types, namely, RW with neoprene sheath or type TW, rubber insulation.

Mr. Mortenson: All right, "E," Screen Room, outdoor conditions, water. That is not bad except there is a tremendous amount of water and the vapor conditions are bad. Quite a bit of power, lot of small motors. But it's in the 600 volt class. What do you say?

Mr. Cooke: Same thing as "C."

Mr. Hogan: Water and vapor are the same thing.

Mr. Mortenson: Okay, we will ditto "C." Now for "F," Size and Alum Plant, indoor conditions, water, steam, alkaline solutions (size), acid solutions (alum). Not so many motors. Well, will what successfully stand up in the digester room where we have alkaline liquors to contend with stand up with acids?

Mr. Hogan: Yes.

Mr. Morteson: Okay, ditto "C." All right, "G," Jordan Room with indoor conditions, water. There we can consider aerial cable.

Mr. Hogan: Aerial cable usually is used outdoors.

Mr. Mortenson: What have I heard about some new mill on the West coast using aerial cable indoors?

Mr. Smith: I think that was just outdoors.

Mr. Clapp: We don't have much distance to run from the Power Plant usually. The motors are pretty close.

Mr. Cooke: You might run into Code difficulties with an aerial installation. (Book is shown Mortenson by Hogan.)

Mr. Mortenson: It is different from what I thought. I see what you mean.

Mr. Cooke: The specification should be the same as "A," namely neoprene sheath.

Mr. Mortenson: Aerial cable out. "H," Machine Room, and we have pretty good conditions, indoor, steam and water is all with voltage up to 6600. Let's say 440 to 6600.

Mr. Smith: The heat is pretty bad. I have used varnished cambric there.

Mr. Hogan: Yes, and it's perhaps as good as anything you can get.

Mr. Smith: You do have a great deal of moisture to contend with and hot humid atmosphere.

Mr. Cooke: You can't keep that out of your conduit very well. Think again that neoprene-jacketed insulation would be best.

Mr. Mortenson: All right "I," Finishing Room, indoor conditions. Here is a simple one. Nice indoor condition with low voltage, so we can ditto "C." All right "J." We have the same thing there—Bag Plant, indoor conditions, so ditto "C" again.

Now, here is one of the worst—"K," Causticizing Plant, lime, green liquor, white liquor, steam, lime mud, with outside conditions. What will we settle for here?

Mr. Cooke: I think "C."

Mr. Hogan: If you asked the manufacturers' opinions they would say "C."

Mr. Mortenson: Now we contact something different in "L," Bleach Plant, chlorine, caustic soda, sodium hypochlorite, sulphur dioxide (sodium peroxide, steam, water.)

Mr. Smith: Just one question, what effect would turpentine content have on neoprene?

Mr. Cooke: I cannot answer your question. I intend to turn this over to my people when I return home and ask their opinion and your questions will be answered.

Mr. Mortenson: This "C" recommendation should be okay.

Mr. Clapp: Sodium hydroxide makes rubber brittle.

Mr. Mortenson: How about synthetic rubber, will it stand up better than natural rubber?

Mr. Hogan: It is different when you are dealing with 50 or 60% composition. It is really dependent on the sheath rather than the rubber. I think it would be all right. Generally the only thing that will attack neoprene to any extent is petroleum solvents.

Mr. Mortenson: Is lead impervious to all this stuff?

Mr. Hogan: No.

Mr. Mortenson: All we can say is duplicate "C." Now Evaporator room, outdoor conditions, 600 volts, black liquor, water steam, number of small motors, transfer pumps, etc.

Mr. Smith: Same as "D."

Mr. Cooke: "D" is the same as "C."

Mr. Mortenson: Now "N," the Recovery room. Here we do have heat to contend with almost the same as in the Power plant. So what will we say? I know that what we put in here no longer than 4 years ago, due to nothing other than that combination of heat, fumes, and chemicals, has had to be snapped out and renewed. So whatever is recommended should withstand these elements. The terrific heat should be given prime consideration.

Mr. Cooke: RH cable might be good.

Mr. Hogan: Rubber will stand longer at low temperatures than high. Was that neoprene-sheathed wire?

Mr. Smith: I think it was RH.

Mr. Hogan: As you remove it, what do you find?

Mr. Mortenson: It is as brittle as can be. I wonder if varnish cambric with neoprene sheath would do a better job than rubber.

Mr. Hogan: It is found not to be much better than rubber with neoprene sheath under extreme heat conditions. The sheath fails and then the cable goes downhill fast. Lead sheath cable might be good.

Mr. Mortenson: Well, what's our best bet? I might say there are large motors in that department on fans across which very frequently 2300 volts are employed. So, we have several voltages to contend with up to 2300 and 4160 volts, in the newer installations.

Mr. Cooke: Put in bigger copper to compensate for the heat.

Mr. Smith: That sounds all right.

Mr. Mortenson: Go back to "A"—RH type.

Mr. Cooke: I think it should be clearly pointed out that where we have greater heat we should use RH type.

Mr. Mortenson: "O," that's a nice one, low voltage. Should be same as "C."

Mr. Cooke: Good place for interlocked armor overhead galvanized.

Mr. Mortenson: "P," Boiler Room, about the same as Recovery. You see what Larry says here. "Indoor conditions. Boiler water treating chemicals, steam, water, chemical dusts from recovery, fuel oil."

Mr. Clapp: Boiler water treating chemicals are confined in one small spot. I don't worry about them.

Mr. Mortenson: That would be the same as "N." All right "Q," Power plant turbine room, and there we have everything.

Mr. Hogan: Particularly on generator leads there is a great deal of diversity of opinion as to what should be used.

Mr. Mortenson: On generator leads our preference perhaps should be bus. The runs are usually short. What should we say, gentlemen?

Mr. Cooke: There's a number of pumps in different services as well as the generator leads to consider.

Mr. Mortenson: Yes. But what shall we say for generator leads—bus ducts? Balance what?

Mr. Cooke: For these conditions interlocked armor would be okay.

Mr. Mortenson: What is the consensus on the balance?

Mr. Cooke: I don't think we could make a recommendation across the board.

Mr. Mortenson: Say ditto "C," RH for 13,000.

Mr. Smith: The capacity there is definitely a consideration.

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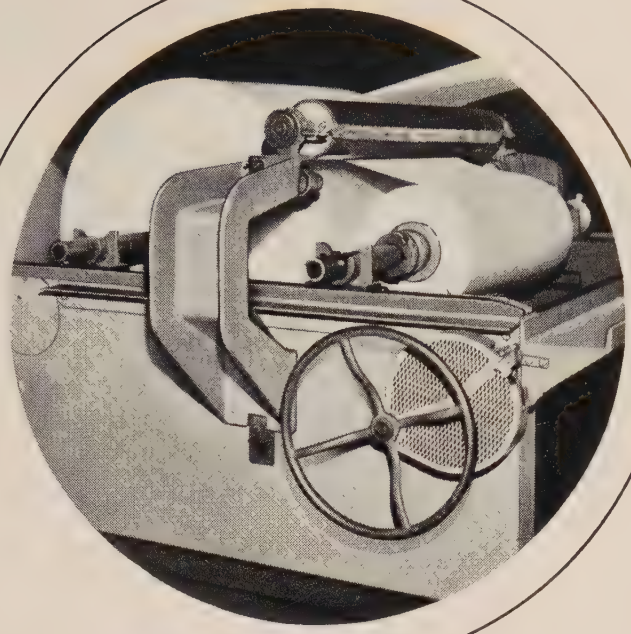

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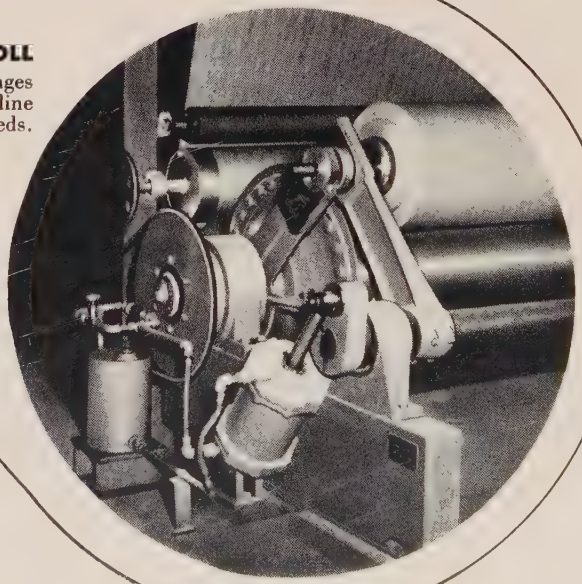

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Mr. Mortenson: What's the consensus on varnished cambric? There is merit in what Smith says.

Mr. Hogan: Yes.

Mr. Smith: General AVC for turbine room.

Mr. Hogan: The conditions are usually good and the room is dry. Varnished cambric with 0.1064-inch cotton tape braid should be okay up to 5000 volts.

Mr. Mortenson: Would it be less costly?

Mr. Hogan: Yes, it would be less costly.

Mr. Mortenson: Well, that is more or less controversial. Now "R," Lime Kiln. Low voltage, outdoors. Discharge end is bad. Terrific heat there and you have to get lines to motors driving conveyors and other gadgets. That lime is red hot. The conditions are entirely different at the feed and discharge ends. We could perhaps ditto "C" for the feed end. But, how about the discharge end?

Mr. Smith: There is the worst condition in the plant.

Mr. Mortenson: Should it be asbestos or what?

Mr. Hogan: It could use silicone with glass braid. Asbestos does not have very much moisture resistance.

Mr. Mortenson: Can you buy silicone in Nos. 6 and 8?

Mr. Hogan: Yes, but it is expensive.

Mr. Mortenson: Braided jacket?

Mr. Hogan: Yes, glass braid jacket.

Mr. Mortenson: "S," Salt cake storage. Not too much there. Lights are about all. Larry, would you say duplicate "C?"

Mr. Clapp: Yes. Only one big motor in there, about 30 hp.

Mr. Mortenson: All right "T," Service Pump House. Maybe 4 or 500 horse, indoor condition. Good clean place. 600 to 4160.

Mr. Hogan: Same as "A." From the print it looks like it is remote from the rest of the place. You could go aerial to there if you wished.

Mr. Smith: Actually we have an overhead transmission line out to there.

Mr. Mortenson: Here, yes, but not all installations are the same.

Mr. Smith: Yes, that's true.

Mr. Mortenson: "W," Bark burning boiler house, outdoor conditions. Same as "P," Same voltage conditions. Ditto "N."

Now, gentlemen, I just wonder if we can map out some sort of a questionnaire for circulation to the industry. Before we do that perhaps it would be better to discuss for a moment what should be sent by us, as a group, to the industry, on cable splicing, cable termination, tapeing, etc. Has anyone any ideas?

Mr. Hogan: I think special potheads should be used for the termination of single-conductor cable.

Mr. Cooke: 13,800 multiple conductor can be safely terminated without potheads if properly handled.

Mr. Hogan: In paper-insulated cables you have to have pothead whether you want it or not.

Mr. Cooke: I wonder if we should recommend the use of paper cable.

Mr. Hogan: It is really better to use rubber leaded. You will have better luck fixing it in case of rupture than you do with paper cable.

Mr. Mortenson: One thing we forgot, we should have had another plant designation, "Precipitators." What shall we say there? We have voltages up to 40 or 50,000 and frequencies approaching radio frequencies as well as pumps, agitators, etc., at normal frequencies. What should we say?

Mr. Hogan: Most of them use what is furnished by the manufacturer of the precipitator—single-conductor, paper-sheathed cable. These cables could be made of rubber but there has been no demand of consequence for them. The reason for this being that they are more expensive.

Mr. Mortenson: We can say then that for the precipitator itself the stuff that will best withstand the high voltage, whether it is paper or rubber, should be used. But rubber is not in the field you say.

Mr. Hogan: I think we might just as well eliminate this from our discussion because it is more or less special and the demand has not as yet centered itself.

Mr. Mortenson: All right, we will say that for the precipitators themselves the equipment manufacturers' recommendations should be abided by and the recommendations for the auxiliary equipment should be the same as "C." On pothead termination, what shall we say?

Mr. Hogan: It depends on whether you want to use your own methods of terminating or the manufacturers' recommendations. Splicing technique is much the same. For instance, public utilities will not buy individual splicing kits. They save money by buying in bulk. Small users of cable might be found on either side of the fence—bulk or individual job buying.

Mr. Mortenson: I think for extensive renovation and complete new construction or building terminations should be made by following the cable manufacturers' recommendations and using his materials. I think that's as much as we need say.

Mr. Smith: The value of the joint (good or bad) cannot be passed on to the cable manufacturer because everything depends on the workmen who made the joint.

Mr. Hogan: Cable manufacturers' designs and specifications are usually used, however. Aluminum conductors are sometimes used instead of copper.

Mr. Clapp: How about the lighter weight of aluminum and the smaller current-carrying capacity per unit of cross section?

Mr. Hogan: You probably should use larger size. Use of aluminum conductors is recognized by the Electric Code. Splices should be made with a compression type connector.

Mr. Mortenson: I wonder how installation costs run?

Mr. Hogan: It is hard to say. You may have to use larger conduit. The cost should be the same or little more favorable than copper. There is considerable thought being given to the fact that eventually aluminum will be widely used. Copper is getting more scarce.

Mr. Mortenson: What should we say about copper versus aluminum?

Mr. Cooke: From the cable standpoint my own feeling is that at this point we should stay clear of it.

Mr. Mortenson: Now, as to the questionnaire—what do we want the men willing to answer questions, who are to be found on the continent in the industry, to tell us. We want to know the reasons for cable failure among many, many other things. Can we get up such a questionnaire? Can we, let's say, submit to each individual a drawing or print on the order of the one submitted to us by Smitty? If we could, he could then change the plant designation to fit his particular plant and with this as a guide we could ask him to submit the same thing to us to cover his particular plant, as we have dug out today for this plant; and then we could prepare a sheet with the same departmental nomenclature where we know it would apply and ask him to tell us what in his judgment, borne of experience, does he consider best to use in the different departments of his mill. How does what I have said sound?

Mr. Hogan: Do you think the fellow would be discouraged from answering if we gave him too much work to do?

Mr. Mortenson: Yes, you bet I do. A questionnaire came in to me the other day that made my heart sink. So, I know what a wet blanket these questionnaires can be.

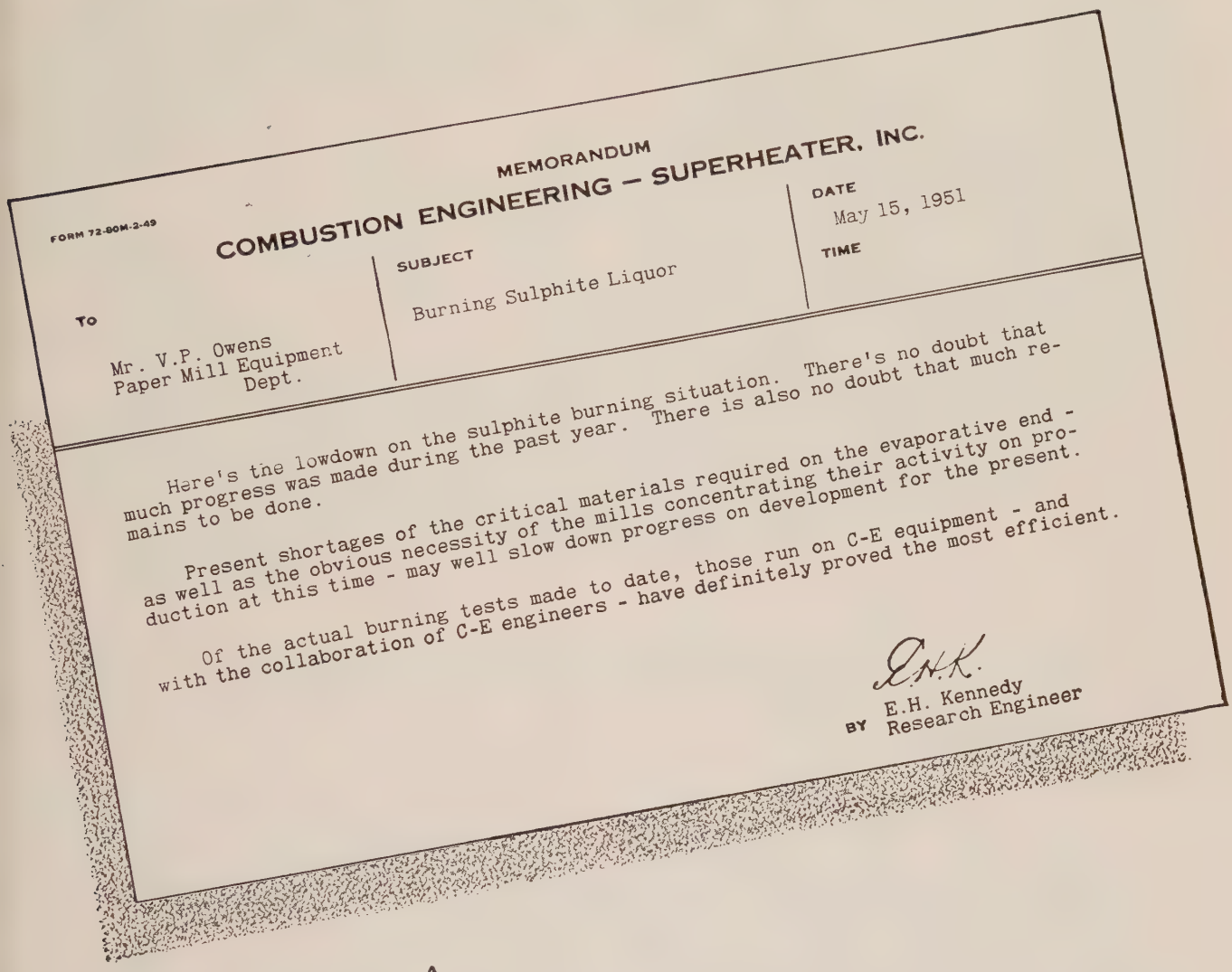
Mr. Smith: Let's work it up in as simple a form as we can.

Mr. Hogan: Write it and word it in such a way that only check marks (✓) would be necessary. For instance:

A System Voltage

Check one of the following system voltages that are in

The present picture on burning Sulphite Liquor



FORM 72-80M-2-49

MEMORANDUM

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TO

Mr. V.P. Owens
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Dept.

SUBJECT

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DATE

May 15, 1951

TIME

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E.H.K.

BY E.H. Kennedy
Research Engineer

As development in this field moves forward, Combustion Engineering-Superheater, Inc. will continue to lend its complete facilities of experience and technical "know-how" to assist the pulp and paper manufacturers in finding the real answer to this important problem.

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Should we mention IPCEA?

Mr. Mortenson: Yes.

Mr. Smith: Inasmuch as we have been requested by two people to conjoin with IPCEA it would seem to me that we should get it in the meeting.

Mr. Hogan: About wires and cables for use indoors where the cable is installed in wet locations, we would like to know the IPCEA recommendations of the wires and cables they consider best for this use.

(During the following hour the questionnaire form was outlined and roughly drawn up.)

(Mr. Tom Manning of Okonite arrived at 4:15 p.m.)

Mr. Mortenson: Well, so that Tom Manning will know a little bit of what we have done today, he having a casual interest with what we are doing in that he has consented to sit in with us this afternoon as a guest, it is no more than fair to let him know what we have talked about. John Hogan, immediately after we got under way (after the purpose of the meeting had been stated and some of the difficulties encountered in bringing the meeting about had been rehearsed), said that we should look in on what was purchased in the way of power, what was, of course, generated within the industry itself and thought that we would find that the range ran from 480 up to 15 kv. and he suggested rubber-insulated neoprene-sheathed for everything above 4160 (shielded type). Other insulations that we should consider seriously are plastic, varnished cambric, ACV asbestos, felted asbestos, AIA type with asbestos braid for resistors. For any of the applications in the voltage range 440 to 4160 we think interlocked bronze armored cable could be used. After lunch Mr. Clapp raised the question of whether we should use bronze. Certain chemicals encountered in the industry affect bronze detrimentally, he said. That was left as a question to be answered later by Mr. Cooke, I think. In that range 440–4160 standard cable incased in conduit was also strongly suggested. In fact, that's about all that is being used in the industry today. That was, by the way, Mr. Manning, taking into consideration the various departments in sulphate pulp and paper mills south of the Mason and Dixon line. We were prompted by what Larry told us we could expect to subject the cable to in the various departments of a sulphate mill. In the Digester Room we do the same as in the Wood Room. In the Brown Stock Washer Room we say general plastic, TW type, or RW with neoprene sheath in a room where there is considerable steam, black liquor, etc. Then in the Screen Room, the Alum and Size Plant we say the same thing as we say for "C." In the Jordan Room we say the same thing, except that we do say that where we consider aerial cable that we should not consider it too seriously. Machine Room where we encounter 440 to 13,800, rubber insulation neoprene jacket, RH type. Finishing Room and the Bag Plant and the Causticizing and the Bleach Plant and the Evaporator Room we duplicate what we said for the Wood Yard and Digester Room; except in the Bleach Plant which is to be investigated by Mr. Cooke and Mr. Hogan because of the chlorine encountered there. In the Recovery Room, where aside from bad chemical conditions we also have high temperature to contend with, we say the same as the Wood Yard, except we say the RH type should be used with sufficient additional cross section in the conductor to compensate for the excessive ambient temp. We have found here that certain cables recently installed, rubber-insulated type, had to be removed in a short time due to high temperature which, according to Mr. Hogan, made the insulation brittle and filled it with cracks. We had to pull it out. So to slow up that action we think perhaps that wire or cable of larger cross section should be used. In the Machine Shop we consider bus duct as the best bet. We have thought about interlocked galvanized armor overhead. In the Boiler Room we duplicate the recommendation shown for the Recovery Plant. Turbine Room there it is a toss-up. Voltage from 13,800 down to 2300. For generator leads we considered bus duct. For the auxiliaries we dittoed the RH recommendation found under Wood Yard and Digester. Smith then threw in a suggestion that perhaps AVC should be specified throughout the Turbine Room. Varnished cambric means lower cost. Then for the Lime Kiln (feed end and drive) we say the same thing as under the Wood Yard. Discharge end, where temperature runs higher than in the Boiler Plants, the suggestion is asbestos or silicon insulation with glass braid. Salt Cake Storage, most anything will do there. For the Service Pump House, we say that what will do in the Wood Yard will do there very nicely. It was suggested that aerial cable had possibilities in getting service to the Pump House. The Bark Burner House came in for the same recommendations as the Main Power House. On the Precipitators we were a bit stumped. 600 to 50,000 volts, with frequencies from 60 cycles to radio. So, for the precipitator equipment itself, where the high voltages and frequencies are employed, our recommendation is that the manufacturers' recommendations be accepted and that the materials furnished by them be used. For the auxiliary equipment we say rubber-insulated neoprene-jacketed.

In discussing cable splicing, cable termination, method of making joints, tapping, etc., we concluded that potheads should be used for all outdoor cable terminations. On all big jobs, whether they are just extensive renovation jobs or complete new construction jobs, we think the terminations and joints should be made in accordance with the cable manufacturers' recommendations. We think, too, that the cable manufacturers should supply the materials used in the joints and terminations because no installation is any better than the poorest joint or splice in the system. Of course the big responsibility rests with the overseers of the workman because the best materials are no good if they are not applied right.

I believe, gentlemen, that that gives Tom Manning a résumé of what we have done here today, and now I am going to relax a moment. Before we declare this meeting adjourned, can we get an expression from those at the conference table as to their opinion of what has been accomplished here today.

Mr. Smith: I think we have made splendid progress. The only thought I have is that, have we succeeded in attaining the aims that we started out with in the beginning. Will this information that we have gathered together and are gathering together result in a set of standards that can be applied to any of the buildings mentioned. If it does, then we have been successful.

Mr. Hogan: I don't think we will ever come down to one certain type of insulation for any installation. We will probably have to recognize two or three different kinds of rubber insulation and that will be up to purchasing personnel.

Mr. Smith: Of course we can't consider the bill complete until we have had replies from this questionnaire.

Mr. Mortenson: Gentlemen, we will stand adjourned until after we have given people in the field a month or two to reply to our questionnaire; then perhaps we can, in some fashion, maybe by mail, perhaps by another meeting, continue our discussions.

I certainly want to thank you, everyone of you, for the cooperation you have given TAPPI; and I want to go on record as expressing TAPPI's appreciation to Simplex and Rome Cable, who through their Messrs. Davis and Wolf respectively, have shown a fine attitude toward the work we are engaged in.

A. O. Mortenson, *Chairman*
TAPPI *Cable Subcommittee*
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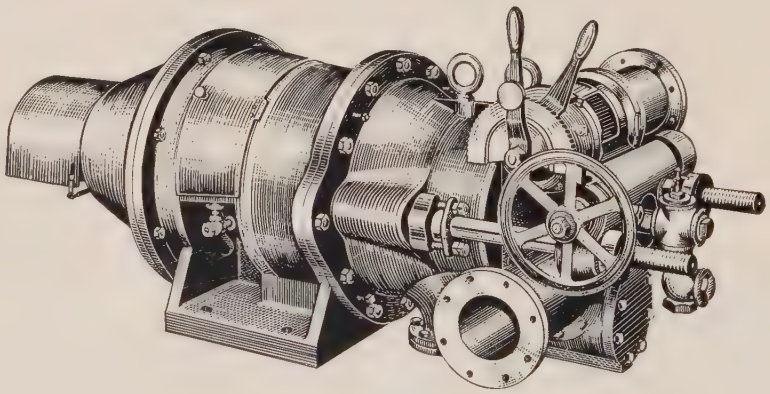

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LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Maine-New Hampshire

The Maine-New Hampshire Section held its annual meeting at Eastern Slope Inn, North Conway, N. H., on June 22–23, 1951. About 300 attended. George A. Day of the Brown Co., Berlin, N. H., presided at all sessions.

Visit to Brown Co. Mill

On Friday morning, June 22, a large group visited the mills of the Brown Co. at Berlin, N. H. Of special interest was the Burgess kraft mill which began operation in 1948 and makes 200 tons of kraft pulp per day from local hardwoods and softwoods. Fifteen men are required per shift. The digester capacities for softwoods are 20 cords (75,000 pounds) and for hardwoods 17 cords (78,000 pounds). The cooking pressure is 95 pounds gage, using indirect steam with circulation. The softwoods are cooled two and one-half hours and the hardwoods three and one-quarter hours.

The washed pulp is stored in slush form in silos and then screened and routed to the paper mills by pipeline; to the wet machines, or to the pulp driers. The pulp is used in making Nibroc towels, Nibrocel, and specialty papers such as twisting, asphalting, and gumming grades, potato sack, sandpaper backing, etc.

A digester blow steam recovery system supplies the mill's hot water requirements. The fuel value of the concentrated black liquor which is burned in the recovery boilers is about half that of coal. The by-product steam generated in the waste-heat boiler of the recovery system supplies nearly all of the mill's steam requirements. A small amount of sulphate turpentine is recovered from the digester relief gases and is burned in the recovery system in the interest of odor abatement. The flue gas from the recovery boiler is treated in a Cottrell electric precipitator to recover entrained chemical and to minimize the dust discharged from the stack. The Cottrell unit has been found to operate at efficiencies of 97%. The chemical raw materials, totaling about 50 tons per day, are efficiently handled at the railroad siding by one man using vacuum unloading systems.

Of particular interest to the visitors was the famous "Mr. Nibroc," the newest paper machine of the Brown Co.

Technical Sessions

The technical program was devoted to a symposium on "Semichemical Pulp Manufacture." George A. Day of the Brown Co. presided during the presentation of papers by J. N. McGovern, Forest Products Laboratory, Madison, Wis.; R. M. Jones and T. E. Detcher of the Barrett Division, New York, N. Y.; C. K. Textor, Bauer Bros. Co., Springfield, Ohio; Tany Agronin, Shartle Bros. Machine Co.; Middletown, Ohio; and T. W. Small, Jr., Sprout, Waldron & Co., Muncy, Pa.

L. to r.: John L. Parsons, T. E. Kloss, both of Hollingsworth & Whitney Co.; H. J. Perry, Paper Trade Journal; H. E. Pratt, Pejepscot Paper Co.; G. A. Day, Brown Co.; A. E. Bachmann, Missisquoi Corp.; W. F. Daniell, Great Northern Paper Co.; R. G. Macdonald, TAPPI; J. J. Thomas, S. D. Warren Co.; and L. C. Jenness, University of Maine.

On Saturday morning W. A. Kraske of the Solvay Process Co., Syracuse, N. Y., led a round-table discussion of the papers that were presented on Friday. The papers presented, with the exception of that by Mr. McGovern, are published in this issue of *Tappi*, pages 88 A to 108 A.

The following is a digest of the subjects presented by the afore-mentioned speakers.

J. N. McGovern laid the groundwork for the symposium on the neutral sulphite semichemical pulping process. He specifically discussed the variables of cooking and dwelt at length upon the concentration of cooking liquor, temperature, time, versus yield.

R. M. Jones discussed the use of ammonium versus sodium sulphite and showed that the two were interchangeable as far as yield and quality of pulp were concerned. Depending on geography (i.e., freight rates) ammonia has a slight advantage. The ammonia-cooked pulp has a darker color in the unbleached state but no more bleach is required to get the same brightness than is required for the sodium cook.

C. K. Textor described in detail the Bauer double and single disk refiners, emphasizing that laboratory data are not reliable and mill work must be the ultimate means of verifying theories. He divided the refining of the stock into three categories, namely, the disintegration of the cooked chips, actual refining of the fiber, and dispersion of the extraneous materials.

T. Agronin described in some detail the Shartle system of complete refinement from disintegration of chips to delivery to the paper machine. Especially discussed was the new drubber which is the primary disintegrator of the cooked chips.

T. W. Small discussed the single disk Sprout Waldron refiner in detail. The outstanding feature is the choke ring which is used to hold back the stock, thus increasing the dwell time for refinement.

The panel discussion on Saturday morning brought out the questions that were not allowed to be asked the previous day. The discussion was lively, complete, and at times amusing.

W. A. Kraske of the Solvay Process Co. extemporaneously covered the aspects of bleaching of semichemical pulp and chemical recovery of the cooking liquor. There are eight processes under study for chemical recovery but the most logical is when it is in conjunction with a kraft mill recovery system. He preferred the three-stage bleach, namely, chlorine-caustic-hypochlorite. Other topics discussed during the panel discussion covered: relative costs of the semichemical process; economics of recovery; the higher yields obtained by this method of handling hardwoods; disk vs. cone refiners, shortcomings of the process, especially the inherently short fibers; the fact that semichemical pulps should be used in conjunction with other pulps; little is known yet about the printability of this new pulp.

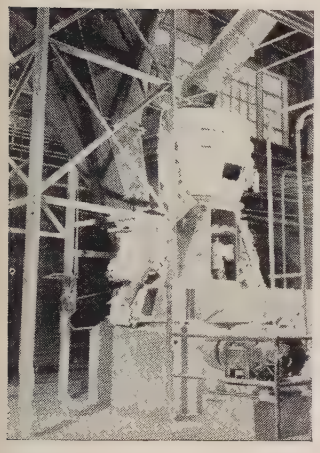
Technically the program was a complete success, due in no

KAOLIN CLAY FACTS... *for Paper Makers*

NUMBER 11 OF A SERIES FROM THE J. M. HUBER CORPORATION LABORATORIES
COMPLETE SET OF THIS SERIES AVAILABLE ON REQUEST

CLAY MINING TODAY—Modern large scale operations require high powered equipment for removal of overburden and mining of clay. Stripping of dirt is accomplished by either mechanical shovels, drag lines, elevating graders or by tractor and pan. Dirt is hauled to dump either by truck, large semi-trailers or conveyor belts. Clay is mined in open pits with high powered mechanical shovels and transported to the plant either by trucks, large semi-trailers or, in some cases, narrow gauge railroads. At the plant, the crude clay is reduced to small lumps by roll crushers or similar devices and stored, according to grades, in separate sheds.

Stripping overburden at a Huber mine.



Raymond pulverizing mill used in dry, or air-flotation process.

PROCESSING CLAY BY THE DRY METHOD—Airfloated clay is made by the dry process, which involves pulverizing the dried crude clay and separation of excessive coarse impurities, the particles of desirable fineness being lifted from the grinding chambers by air currents, while the coarse particles are rejected from the upward stream by whizzer type separators. Air-flotation plants consist essentially of a rotary type dryer, a high side Raymond Roller Mill with whizzer separator, a cyclone collector and bin, and a means of conveying the finished product to storage or car.

The crushed crude clay, containing approximately 20–25% moisture, is fed in a uniform continuous stream into the rotary dryer from which it emerges at a moisture content of 1–2%. The dried crude clay is elevated to a storage bin which feeds directly to the Raymond Mill. Pulverization of the clay is accomplished by means of the centrifugal pressure of the mill rollers exerted against a bull ring.

Have you received your copy of "Kaolin Clays and Their Industrial Uses"—new Huber 144-page technical reference book? Write on your company letterhead.

MODERN COATING METHODS—There are two main types of coating methods: 1) those which apply the coating film after the base stock has been manufactured, the coating equipment being entirely independent of the paper machine; and 2) those which apply the film while the paper is being produced, the coating equipment being an integral part of the paper machine. The terms "off the machine" and "on the machine" are generally used to describe the two methods.

Clay is the predominant pigment used in coating. Coating clays are especially light colored and of specified particle size distribution. Depending upon the desired effect, the clay is used either alone or in combination with other pigments. When such a paper is calendered, the result is a smooth, even-textured surface, with a micro-porosity which helps to absorb the ink vehicle—reproducing with remarkable accuracy fine halftone engravings.

Particle Size Distribution of Typical Huber Coating Clays

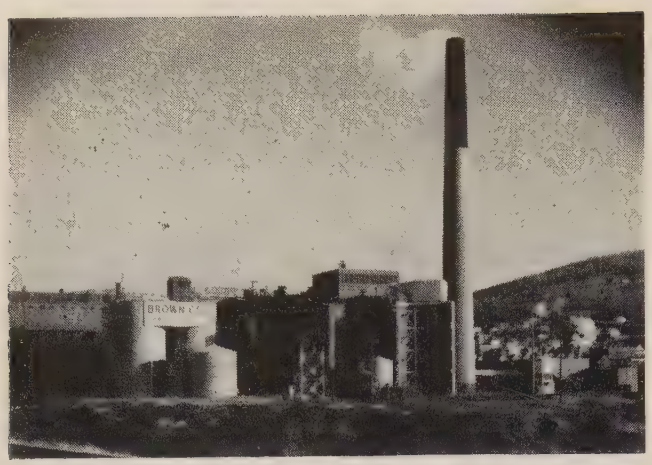
Micron Diameter	Special Hydratex	Hydratex
Above 10	0.0%	1.0%
5–10	3.3	6.6
4–5	2.8	4.2
3–4	4.8	6.8
2–3	8.6	9.4
1–2	15.4	15.3
0.5–1	17.2	16.0
0–0.5	47.9	40.7
Above 5	3.3	7.6
Finer than 2	80.5	72.0

HUBER

J. M. HUBER CORPORATION, *100 Park Avenue, New York 17, N. Y.*

MINES & PLANTS—LANGLEY, S. C., GRANITEVILLE, S. C., AND HUBER, GA.

ONE OF THE WORLD'S LARGEST CLAY PRODUCERS



The kraft mill at the Brown Co., Berlin, N. H.

small measure to the wit and wisdom of John McGovern during the panel discussion on Saturday morning.

Business Meeting

At the business meeting held on June 22 the following officers were elected for the coming year:

Chairman—G. A. Day, Brown Co., Berlin, N. H.
Vice-Chairman—J. J. Thomas, S. D. Warren Co., Cumberland Mills, Me.
Secretary-Treasurer—H. E. Pratt, Pejepscot Paper Co., Brunswick, Me.
Executive Committeemen—O. E. Anderson, International Paper Co., Chisholm, Me. (1 year); A. E. Jones, Oxford Paper Co., Rumford, Me. (1 year); J. F. Wright, National Aniline Division, Boston, Mass. (1 year); W. E. Daniell, Great Northern Paper Co., Millinocket, Me. (2 years); T. E. Kloss, Hollingsworth & Whitney Co., Waterville, Me. (2 years); Henry Hooper, Penobscot Chemical Fibre Co., Great Works, Me. (2 years); J. B. Calkin, University of Maine, Orono, Me. (3 years); W. L. Hinds, Keyes Fibre Co., Waterville, Me. (3 years); F. A. Strovink, American Cyanamid Co., Boston, Mass. (3 years)

R. G. Macdonald, National Secretary, urged the Section to establish committees to prepare routine mill control methods and engineering data sheets, such committees to become parts of similar committees in the national organization. The new executive committee is expected to appoint such committees at a future date.

The next meeting of the Section will be held at the University of Maine, Orono, Me., on Oct. 5–6, 1951. Room reservations should be made at the Bangor House in Bangor, Me.

The Technical Program Committee consisted of G. A. Day and J. J. Thomas; J. Fife Wright and H. E. Pratt were members of the Local Arrangements Committee. Mrs. Richard S. French was Chairman of the Ladies Program. W. D. Stroud of F. C. Huyck & Sons, Portland, Me., was in charge of the golf tournament which was won by Charles Pennings, Jr., with low gross and Sydney Hanks of Brunswick, Me., had the second low gross.

The Nominating Committee consisted of J. L. Parsons, Hollingsworth & Whitney Co., Waterville, Me.; E. L. Lamb, Oxford Paper Co., Rumford, Me.; and R. S. French, Keyes Fibre Co., Waterville, Me.

Ammonia Base in the Neutral Sulphite Semichemical Pulping Process

R. M. Jones and T. E. Detcher

THE neutral sulphite semichemical (N.S.S.C.) process consists briefly of (1) digestion of the wood chips with chemicals which are practically neutral and buffered to retain neutrality during the cook, and (2) mechanical reduction of the softened chips. The process was originally applied to the manufacture of corrugated board-type pulps from hardwood with yields ranging from 70 to 85% on a moisture-free basis. The bleaching of these pulps was not practiced commercially until about 1940 when investigational work by a Barrett Division affiliate, The Solvay Process Division, Allied Chemical & Dye Corp., and the U. S. Forest Products Laboratory demonstrated that a high yield, bleached semichemical pulp could be produced on a commercial scale. The process, utilizing sodium sulphite buffered with sodium carbonate as the cooking liquor, is being used at present in a number of mills for both unbleached board-type and bleached-type paper grade pulps.

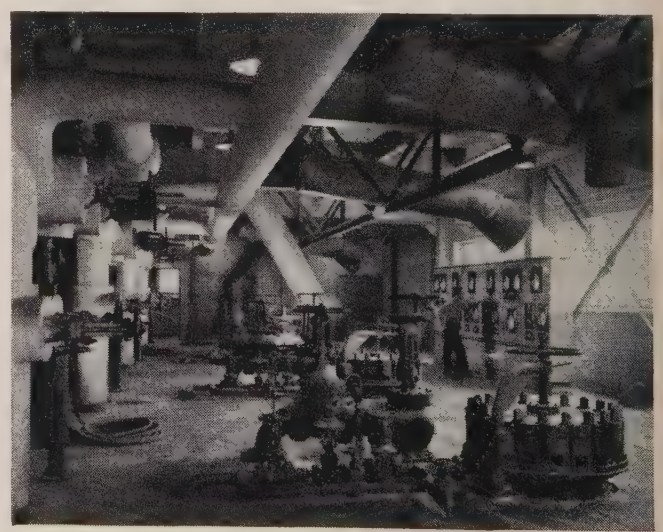
R. M. JONES and T. E. DETCHER, The Barrett Div., Allied Chemical & Dye Corp., New York, N. Y.

HISTORY OF AMMONIUM SULPHITE SEMICHEMICAL PULPING

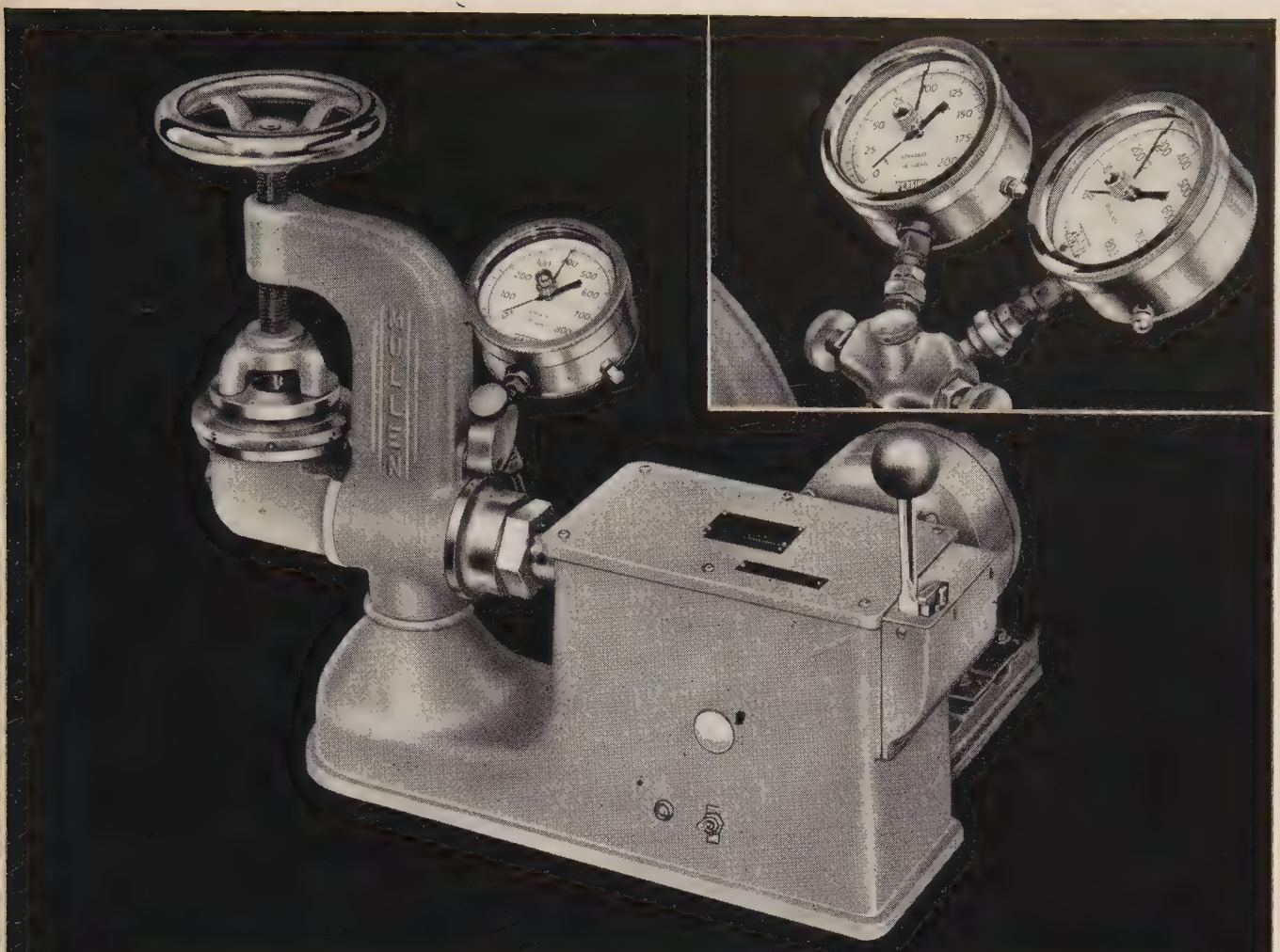
The use of ammonium sulphite as a cooking agent was first proposed by Brauns (*1*) in 1902 who made small-scale cooks with this chemical. Numerous other investigators, Rosenblum et al. (*2*), 1912, Sammot and Merrill (*3*), 1912, Brech and Tyborowsky (*4*), 1914, and Harnest (*5*), 1914, studied ammonium sulphite cooking and patented various features of the process. No commercial application of the ammonium sulphite semichemical process was practiced until 1947 when International Paper Co., Southern Kraft Division, was forced to operate one of its southern semichemical plants on ammonium sulphite for several months during a period of soda ash shortage with very satisfactory results.

Early in 1947 the Solvay Process Division, Allied Chemical & Dye Corp., investigated the substitution of ammonia for soda ash in the neutral sulphite semichemical process. In its investigations Solvay used chipped poplar obtained from a Wisconsin mill. Several cooks were made using sodium base and compared with cooks made with ammonium base under similar conditions. Two types of pulp, paper type and board type, were made with each base. The results showed no significant differences in yield, physical and chemical characteristics between the unbleached pulps made from soda or ammonium base. The paper-type pulps were bleached in a three-stage system and evaluated for strength characteristics, yield, and bleach consumption. The results again showed no significant differences between the bleached pulp made from either base.

In the Summer of 1950, there was a critical shortage of soda ash. Four mills, three producing board-type pulp and one producing paper-type pulp, were operated on ammonia base. Two of the board mills have discontinued the use of ammonia



View of the top of the digesters in the Brown Co. mill



Model A Mullen Tester tests specimens with bursting strength above 200 pounds per square inch. Model C tests any paper or paper product in sheet form not in excess of .025" thickness. Note two-gauge mounting for testing materials of widely different strengths.

Perkins Mullen Tester searches out any imperfection or weak section of the area of material under test, protrudes into that weakness wherever located and registers the resultant breaking point. The burst actually represents what strain would do to the material in actual use and measures that strain, as the fibers are torn, at the very point of weakness. Throughout the world, the Mullen Test is recognized as the standard bursting test because the Mullen Tester indicates actual bursting strength irrespective of any other factor.

B. F. PERKINS & SON, Inc.

HOLYOKE, MASS., U.S.A.

The wet end of "Mister Nibroc"

base while one mill producing board-type pulp and one producing paper-type pulp have continued its use.

AMMONIA VS. SODA ASH

Ammonia is shipped to the consumer in tank cars as liquid anhydrous ammonia. This will unload itself into water under its own vapor pressure to make ammonia liquor, usually of 30% NH_3 concentration. The 30% ammonia liquor is stored in low pressure tanks and metered to the sulphiting system where it combines with the SO_2 from the sulphur burners.

Because ammonia is shipped as an anhydrous liquid it can be delivered to most mills in equivalent chemical quantities for less than the cost of soda ash. The following table shows the comparisons between the delivered cost of anhydrous ammonia and soda ash, delivered to several mill destinations:

	Anhydrous ammonia delivered, price per ton,$	*Soda ash delivered, price per ton,$*	*Ammonia equivalent of soda ash,$*	*Savings in favor of ammonia per ton soda ash,$*
Berlin, N. H.	97.60	32.00	31.13	0.87
Augusta, Me.	98.80	32.20	31.62	0.68
Waterville, Me.	99.00	32.40	31.68	0.72
Rumford, Me.	99.00	32.40	31.68	0.72
Bucksport, Me.	100.60	33.40	32.19	1.21

These figures are based on anhydrous ammonia at $80 per ton and bulk soda ash at $24 per ton f.o.b. nearest producing point. The ammonia equivalent to soda ash is calculated on the basis of 34 pounds of ammonia equivalent to 106 pounds of soda ash. You will note that for each destination shown there is a saving in favor of ammonia on the basis of the stoichiometric equivalent. As will be shown later, there are some indications from commercial operation on ammonia base that for the same yield less ammonia is required than its equivalent in soda ash.

In addition to the saving in chemical cost there is usually a saving in labor in handling ammonia as a liquid over soda ash as a solid.

PREPARATION OF THE COOKING LIQUOR

The preparation of the cooking liquor with ammonia is basically the same as with soda ash where a tank is usually filled with a predetermined amount of water and soda ash and the solution sulphited by recirculation over a tower to the proper ratio of sodium sulphite to sodium carbonate. In the ammonia process this procedure must be modified slightly to prevent loss of ammonia in the sulphiting tower. Water is fed to the sulphiting tank and a small amount of ammonia liquor is added to produce a slight initial alkalinity. The recirculating system is then started. Dilute ammonia solution from the tank is pumped into the sulphiting tower and flows downward countercurrent to the SO_2 burner gas. Ammonia liquor is metered to the tank in amounts necessary to combine with the SO_2 to form ammonium sulphite. The system is kept on the alkaline side to prevent acid corrosion. This operation is continued until the proper concentration of ammonium sulphite is reached. In the ideal two-tank system the burner gases are then switched to the second sulphiting tank containing dilute ammonia solution and the same procedure is followed.

To the ammonium sulphite solution in the first tank additional ammonia is added to the desired level. During this operation circulation must be discontinued to prevent loss of ammonia through stripping in the sulphiting tower. The concentrated liquor from the sulphiting tank is diluted with water or recirculated black liquor and pumped to the digesters.

DIGESTER OPERATION

Cooking with ammonia-base liquor is very similar to standard soda-base semichemical procedure. In soda-base operation considerable gas pressure is built up in the digester due to the residual CO_2 remaining in the cooking liquor in addition to the gases normally formed in cooking. This pressure must be relieved to maintain proper pressure and temperature conditions.

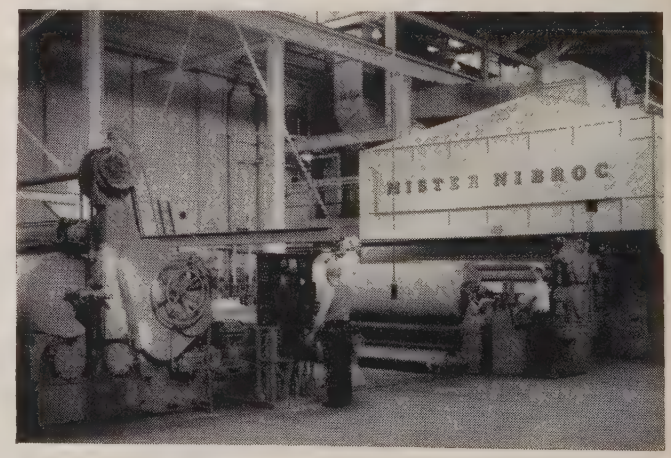
In the ammonia process there is no CO_2 liberated from the cooking liquor. Pressure relief of the digester is still necessary to maintain proper cooking conditions but can be delayed until later in the cooking cycle. Otherwise the volatile free ammonia may be reduced below that necessary to neutralize the acids formed during the cooking process. Acid condition in the final stages of the cook may produce a serious corrosion effect on the mild steel equipment. This condition may be overcome by the continuous addition of ammonia liquor to the digester to maintain proper pH conditions as the cooking progresses. End point pH values could be selected based on the requirements of the particular system which would hold to a minimum residual free ammonia in the pulp and black liquor.

OPERATING EXPERIENCE

As stated previously, mill scale runs have been made at four plants. For the purpose of this paper we will confine our remarks to the operating experience of two mills, one producing board-type pulp and the other producing paper-type pulp.

AMERICAN BOXBOARD CO., FILER CITY, MICH.

This plant uses a one-tower, two-tank liquor make-up system and operation is continuous. Sulphiting was carried out with the solution in the tank being kept slightly alkaline. The additional buffering ammonia was added after the sul-



The dry end of "Mister Nibroc"

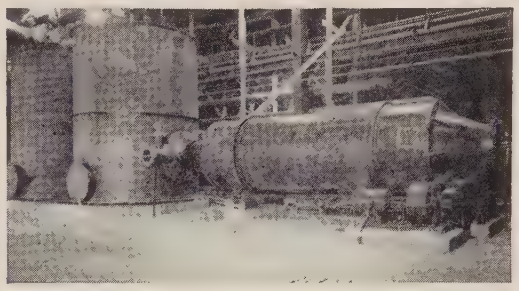
G. D. JENSSEN

RAW ACID PLANT

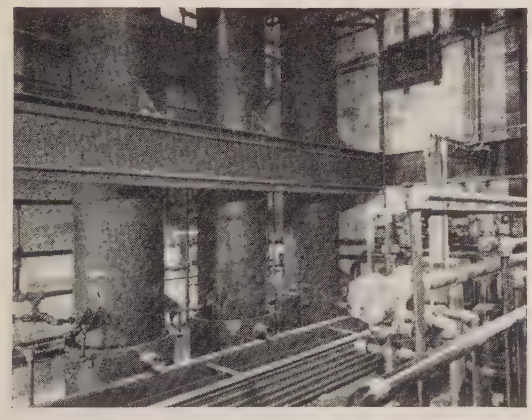
At Watson Island Mill of

COLUMBIA CELLULOSE CO. LTD.

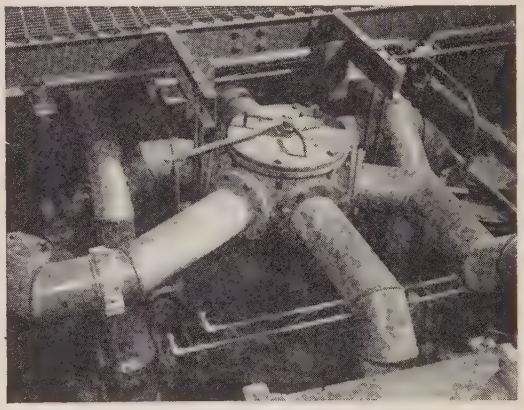
Jenssen Towers With Skip Hoist and Man Lift Elevator



Jenssen Rotary Vaporizer Tandem Combustion Chambers



Jenssen Tubular Sulphur Melters



Jenssen Six-Way Acid Valve Assembly

G. D. Jenssen Co., Inc., designed and built the following for the raw acid plant of this new high-alpha pulpmill:

- Sulphur Melting and Molten Storage
- Sulphur Burning Plant
- Spray Gas Coolers
- Acid Towers
- Pressure Acid Making System
- Settling Tank and Acid Filters

We are also Designers and Builders of:

Jenssen Pressure Acid Systems, Jenssen Auxiliary Process Towers, Recovery Plants—Cooking Acid, Soluble Base Acid Plants, Semi Chemical Plants, Jenssen SO_2 Absorption Systems, Sulphurous Acid Preparation for Bleach Plant Application.

G. D. JENSSEN CO. INC.

330 Electric Building **Watertown, New York**

phiting of the batch was completed. The circulated liquor was passed through a heat exchanger which reduced loss of free ammonia to a minimum. Poplar was pulped in converted vertical sulphate digesters equipped with forced circulation. Stock was blown into a modified kraft blow tank and washed before refining. Primary refining was accomplished in Sprout Waldron and Bauer refiners. Sutherland refiners are used for final stock preparation prior to the production of 9-point corrugating on a Beloit fourdrinier. Part of the 9-point produced is used in American Boxboard's own operations and part marketed as such. Initial liquor-to-wood ratios were calculated from the molecular equivalent of ammonia to the soda base previously used. This resulted in an excessively soft pulp of poor strength. When the amount of chemical to wood was sharply reduced, strength values approaching those from soda base resulted. The flat crush of ammonia-base board was reduced slightly but at the time of the initial work in this mill substantial changes in refining equipment were made, Sutherlands being substituted for jordans. Consequently, it was difficult to ascertain the exact cause of variations in pulp characteristics.

Some difficulties were experienced in maintaining end point pH values up to desired levels but acceptable board was produced.

American Boxboard is continuing the alternate use of ammonia and soda ash.

CONSOLIDATED WATER POWER & PAPER CO.

In August, 1950, because of the soda ash shortage, Consolidated decided to use ammonia in its semichemical plant. The physical details of this plant were described in the August, 1950, issue of *Pulp & Paper*.

Liquor Plant. Because of the need for speed in changing from soda ash to ammonia, and the lack of storage facilities for aqua ammonia, anhydrous ammonia was piped directly to the sulphiting tanks. The tank was filled with water, the ammonia valve opened, and circulation through the absorption tower started with admission of SO_2 burner gas.

The rate of ammonia feed is adjusted to the sulphiting rate to keep the solution slightly on the alkaline side and the composition checked by frequent titrations. This procedure is continued until a concentration of 1 pound per gallon of ammonium sulphite is reached, with only a slight excess of ammonium hydroxide present. SO_2 admission is then discontinued and the ammonia flow continued until the free ammonia reaches a ratio of 5 to 1. The finished cooking liquor is then pumped to storage.

Cooking. For cooking, two Manitowoc vertical-type digesters were used. Thoroughly cleaned and seasoned aspen (Wisconsin poplar) chips were charged to the digesters and cooking liquor to provide 5.2% total NH_3 pumped in. It has been found that this quantity of total NH_3 produces a cooked chip quality and yield comparable to 17% soda ash, a definite saving in base.

The liquor is continuously circulated and distributed through a cone spray nozzle at the top of each digester.

A smooth cooking curve is used allowing ample penetration time to 115°C. and then going to 175°C. maximum at 110 p.s.i. pressure. Total time, cover to cover, is about $6^1/_2$ to 7 hours. Due to the absence of bicarbonate, CO_2 is not given off when steaming up the digesters, and much less venting is required than when soda ash is used. Even the short venting period required, however, has been sufficient to cause loss of free ammonia resulting in a serious drop in pH. A cook starting with a pH of 7.7 has been found to drop to pH of 5 to 5.5 after the venting period.

It is normal practice at this mill to vent relief from the white liquor tank for heat recovery. This had to be discontinued when cooking with ammonia to prevent loss of free ammonia. As a result it was necessary to start the ammonia cooks at 20 to 40°C. less temperature than is normal for soda ash cooks. In spite of this ammonia has been found to cook faster resulting in shorter cooking period of $6^1/_2$ to 7 hours compared to 8 hours for soda ash.

Refining. Five double-disk Bauer pulpers broke down the softened chips into individual fibers. The chips were metered to the refiners by direct-driven screws which received the chips from a Link-Belt Bulk-flo conveyor. The cooked ammonia base chips appeared to be drier and somewhat softer than normal soda-base chips, and were darker in color. Ammonia cooked chips have been found to contain more dark centers than soda cooked chips. This has resulted in overrefining to resolve the dirt and the production of a slower stock.

Pulp Quality. Chemical analysis of the ammonia-base pulp showed a tendency toward higher pentosan removal and lower lignin removal than for soda base pulp. At this mill the pentosan content was 15.2% and the lignin content 7.3% for the ammonia pulp as compared to 19.5% pentosan and 6.5% lignin for the soda pulp.

The normal physical tests, burst and tear, were about 5 to 10% lower with ammonia as compared to soda pulp.

Despite the higher lignin content of the ammonia pulp, bleach demand was approximately the same as for the soda pulp producing a clean pulp of equal brightness.

Consolidated is continuing periodic test runs on ammonia.

CONCLUSION

Ammonia base has been successfully used in the neutral sulphite semichemical process in several mills on both board and paper-type pulps. However, the process must at present be regarded as being in the development stage. This report should therefore be considered as a progress report and much remains to be accomplished before the process is ready for full-scale commercial exploitation.

In conclusion, we wish to extend our appreciation to the technical staff of the American Boxboard Co. and to L. W. Murtfeldt, Pulp Superintendent of Consolidated Water Power & Paper Co. for supplying data used in this report.

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1. Schubert, "Die Cellulose Fabrikation," 3rd Ed.
2. German pat. 252,321 (1912).
3. U. S. pat. 1,016,178 (1912).
4. U. S. pat. 1,100,519 (1914).
5. French pat. 156,777 (1914).

Semichemical Pulp Production with Revolving Disk Mills

Clinton K. Textor

The pulp and paper industry abounds with words and expressions for which there is no accepted definition and which are, therefore, rather loosely used. Many of these terms are used by some in a very broad sense, by others, highly specifically. The word "hydration" is a good example of a word which is used to denote a different condition or action according to the conception of the word by the user. And semichemical pulp is another one of these loosely used expressions.

It would seem that the words making up the phrase "semichemical pulp" would imply that a mechanical action is required in connection with a chemical treatment in the preparation of the pulp itself; and that this mechanical treatment is that which is required to produce pulp and does not necessarily include the mechanical "stock preparation" procedures. This broad conception of the term imposes no restrictions whatever on the kind of chemicals used in the preliminary treatment, and similarly does not specify the amount of cooking or chemical treatment that will precede the mechanical action. Any degree of cooking between full cooking and no cooking at all, when it is followed by a mechanical treatment, can properly be considered as semichemical pulping. This broad definition would then include certain procedures

Clinton K. Textor, The Bauer Bros. Co., Springfield, Ohio.

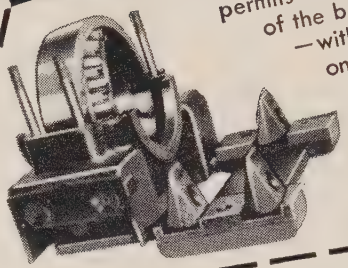
TRAIL BLAZERS to more efficient paper production

Four important developments in paper-making efficiency—some of which are becoming standard practice with bearing manufacturers, *originated with* SKF.

THE FIRST

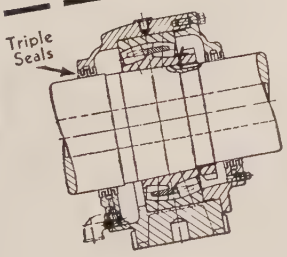
Spherical Roller Bearings applied to paper machinery, with results of smoother paths for power and real operating economies, were SKF Bearings.

THE FIRST



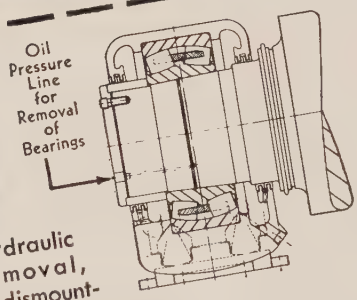
Rocker Mount Design, which permits expansion and contraction of the bearings and driers —with no lateral stresses on the side frames, was an SKF development.

THE FIRST



Triple Seals, for efficient non-rubbing sealing that retains lubricant independent of speed and temperature, were designed by SKF.

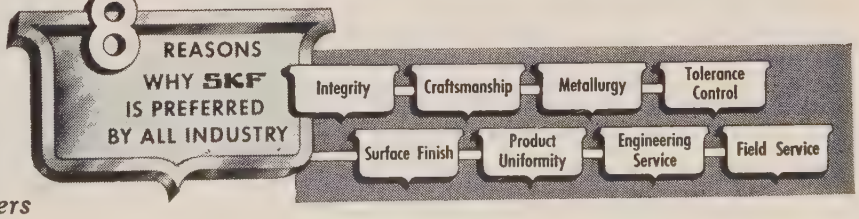
THE FIRST



System for Hydraulic Bearing Removal, where such dismounting of large or small bearings becomes a rapid and easy operation that eliminates damage to bearing and housings, was originated by SKF Engineers.

SKF

BALL AND ROLLER BEARINGS



Yes, SKF, in the paper industry as well as many others, has blazed the trail to more efficient, economical, reliable production. And right now, SKF Engineers in cooperation with machinery builders are *anticipating* the needs of advanced designs of paper machinery — so that years from now production will be even more efficient. SKF INDUSTRIES, INC., PHILADELPHIA 32, PA., *the Pioneers of the Deep Groove Ball Bearing—Spherical Roller Bearing—Self-Aligning Ball Bearing.*

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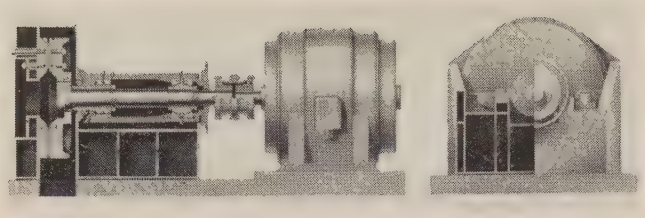

Fig. 1. Single revolving disk mill

which are commonly known by other names such as "high yield sulphite" and "high yield kraft," and might also be considered to include steamed wood in which the cooking chemical is water and acids hydrolyzed from the wood by the water.

On the other hand, a great deal of the literature concerning semichemical pulping has emanated from the Forest Products Laboratory, and a considerable part of that literature deals with the use of sodium sulphite as the cooking agent. Further, a great deal of the Forest Products Laboratory literature describes procedures in which the chips were impregnated with liquor prior to cooking. And so it happens that a great many of the people using the expression semichemical pulp think of it only as that pulp produced with a neutral sulphite cooking, and some of them think of it only as that same cooking preceded by an impregnation of the chips with the sodium sulphite.

In the comments which follow, the broad definition will be taken as a starting point but with special emphasis on pulp produced with neutral sulphite cooking.

Another word that lacks an exact definition is "refining." Years ago, a refiner was considered as any piece of equipment used for mechanical treatment of a fiber after the pulp left the beater. Jordans were definitely classed as refining engines. But in this paper, refining will be used in a broader sense and will include any mechanical device that is used to produce pulp from chips or to develop strength and other properties in that pulp.

Today, refiners are variously used in the production of semichemical pulp. While in most of the current semichemical pulp operations a simple flow sheet is employed, the conventional sequence of chemical treatment followed by mechanical action is sometimes modified with special reference to the type of wood available and the end product desired. For example, the chemical treatment and the initial mechanical action can be carried on simultaneously, or the refiners may be integrated, or partially integrated, with the chemical treating equipment.

While the literature indicates that for certain specific types of semichemical pulps, several different types of refiners may be used effectively, by far the most popular refining equipment employed in semichemical pulp production today are the revolving disk mills.

These disk refiners are simple in conception and are probably merely an outgrowth of the old burr stone mill used in producing flour. A disk mill is merely a device by which one disk can be caused to rotate upon, or in close proximity, to another similar disk. If only one disk is made to rotate, we have a single disk mill; if both disks can be made to revolve simultaneously, in opposite directions, the refiner is known as a double disk unit.

There are two main requirements that must be met in a good disk refiner. First, when in operation and fully loaded, the plane of rotation of the revolving disk must be parallel to that of the stationary disk in a single disk mill; in a double disk mill, the planes of rotation of the two disks must be parallel. Second, the mills must be so designed that the disk or disks can be made to operate at a controlled distance from each other.

The manner in which these requirements may be implemented is illustrated, for the single disk model, in Fig. 1. This unit comprises a rotating disk 44 inches in diameter, it is precision built, to be driven by an outboard motor in any size up to 600 hp., and may operate at any speed up to 1200 r.p.m. It is designed to be fed under pressure, if desired, up to 20 p.s.i.

Figure 2 illustrates a precision type of double disk mill, also designed to accept 600 hp. The speed of each of its two motors may be any desired number of revolutions per minute up to 1500. The motors are integrated with the mill itself, to avoid excessive size of equipment. This type of mill is designed for gravity feed. The machine illustrated is equipped with 36-inch disks, although 40-inch heads are also available for it.

Both the double disk and the single disk unit illustrated are very ruggedly constructed to avoid mechanical deflections. Likewise, in both cases, the bases or frames are water cooled to avoid distortions of parallelism due to thermal causes. And finally, both are designed merely to rest on the floor or foundation, and so maintain their accuracy irrespective of expansion and contraction of the foundation. The no. 430 single disk mill is designed for outboard motor drive, and so must be bolted to the foundation, but only at one place, and this is to avoid tipping action due to the torque of the motor.

Modern disk mill design provides facilities for renewing the working surfaces of the disks. These renewable "plates" are sometimes available in full circles, although generally they are provided in segments, requiring anywhere from three to eight segments for a full circle. A variety of materials is employed in plate production, the most common being white cast iron alloyed with chromium, nickel, and other materials depending upon the use requirements of the refiner. Working surfaces of stainless steel, and of mineral abrasives, have also been used successfully.

A considerable variety of plate patterns are available, for the most part, unscientifically designed to produce the desired refining effect in the mill. A few of these various designs are illustrated in Fig. 3.

While the double and single disk mills are similar in principle, there is a profound difference in their performance. While both mills have a definite tendency to roll any materials between the disks, this tendency is much more pronounced in the double disk mill. Perhaps a corollary to the above is the fact that it is much easier to retain stock between the disk of the double disk mill, when both types are operating at the same speeds. A basis for choosing between the two types of mills will be touched upon in later paragraphs.

OPERATION OF DISK MILLS

Basically, the operation of a disk mill is as simple as its construction. Upon the basis of previous experience or trial runs, the clearance between the disk is set to absorb the desired amount of power. Then the raw material, in regulated quantity and consistency, is fed to the mill through an opening in the center of the head of a single disk mill, or through the openings between the spokes of one of the heads of a double disk mill. The stock is refined as it passes outwardly between the disks and is discharged at the periphery. The refined stock is collected in the case and discharged from the mill through an opening in the bottom of the machine.

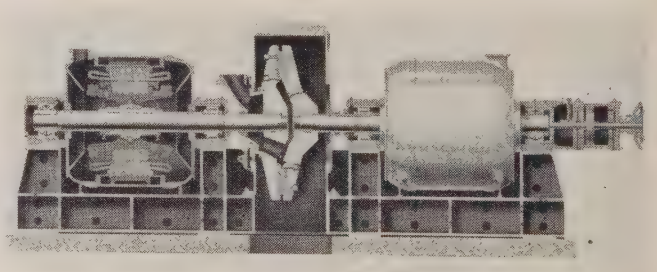

Fig. 2. Double revolving disk mill

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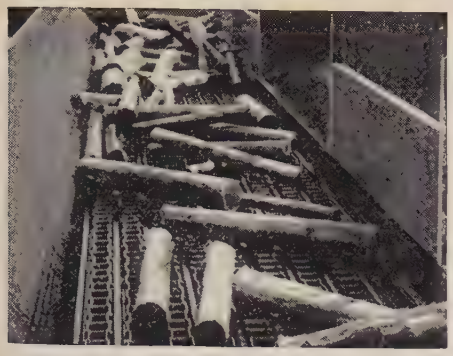

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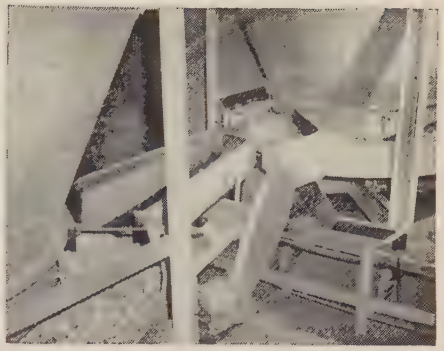

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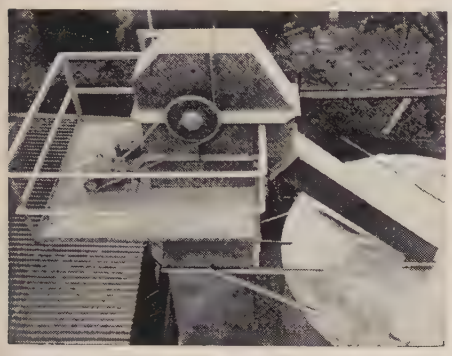

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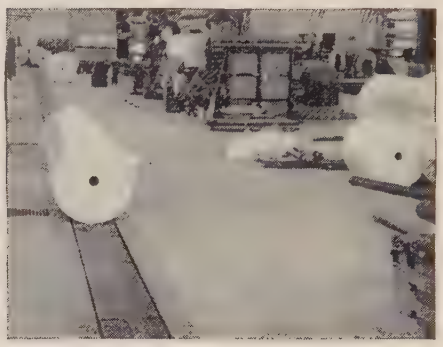

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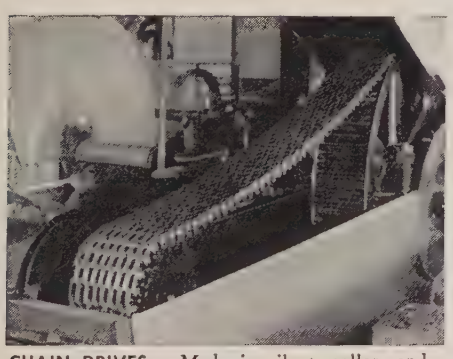

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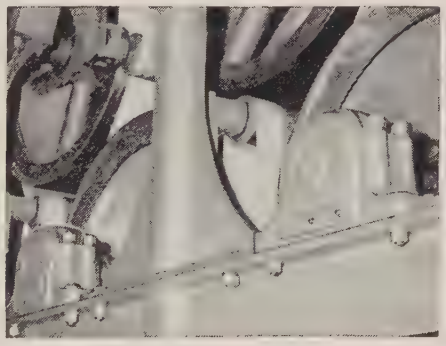

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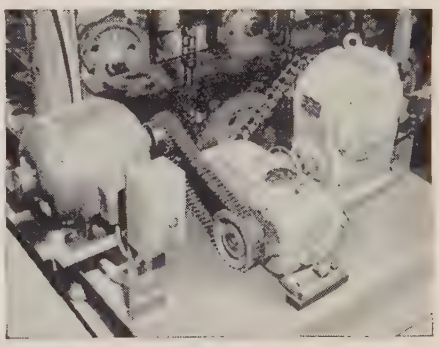

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While the general principle of operation of disk mills is very simple, there are a great many variables which have a profound influence on the quality of refining accomplished, and upon the mechanical efficiency with which this is achieved. The effects and the importance of these several variables are only sketchily known, and the choice of the proper conditions and equipment for disk mill refining continues to be based on actual mill experience, or upon laboratory experiment with a full commercial-sized disk refiner.

In addition to the above-mentioned differences between the action of a single disk and a double disk mill, a proper choice of a mill for a specific refining job must involve the correct choice of such features as speed of rotation, peripheral speed, rate of feed, consistency of feed, temperature of feed, pattern and metal of the refining surface, distance between the rotating disks, and several others of lesser importance.

THEORIES OF REFINING

In spite of the vast amount of scientific research which has been conducted to determine the nature of cellulose fibers and the effect of mechanical treatment upon their properties, the actual practical application of power to produce pulp and to develop the desired physical properties of the fiber remains in the realm of the mechanical arts, or at best in a sort of empirical technology. This applies regardless of whether the mechanical treatment of the pulp is called stock preparation, beating, jordanning, refining, or disk mill treatment.

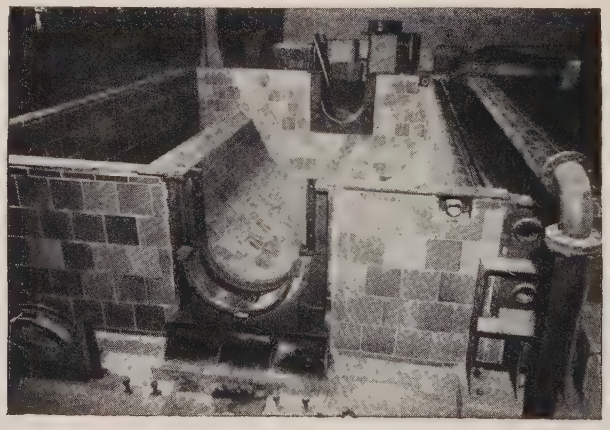
The technology of pulp refining has advanced enormously in the past 25 years. Unquestionably the development of freeness and drainage rate determinations, of pulp strength evaluations, of chlorine numbers, and a host of similar techniques, has served to advance the art of stock preparation. But they serve mainly to reduce the amount of mill scale experimentation with refining, by transferring the investigations to the much less costly basis of laboratory research. This applies in disk mill refining to substantially the same extent that it applies to stock preparation with the conventional beaters and jordans. Just as effectiveness of the usual laboratory investigation is seriously handicapped due to the fact that with miniature laboratory beaters, the technologist is unable to duplicate the performance of commercial jordans, so it is with miniature and commercial-sized disk mills. A miniature disk mill, with an 8-inch disk, approximates the refining action of a 36-inch mill more closely than does any other type of laboratory refiner. But, the quality of refining produced by an 8-inch mill and the power required to achieve results, generally depart widely from the performance of a 36 or 40-inch unit.

While it is the writer's personal opinion that there is no guide for the proper selection of equipment or procedure in disk mill refining except that based on actual commercial experience, or by experiment with a commercial size refiner, the admittedly limited total experience with revolving disk refining seems to have developed some rule-of-thumb knowledge which will serve to guide and reduce the amount of specific experimentation required for a particular application.

The performance of disk mills may be grouped into three categories: (1) fiberizing, (2) strength development, and (3) dispersing. As is the case with most classifications, this one is not clear cut. It is impossible, for example, to do a good fiberizing job and without, at the same time, doing some work in the other two classifications of strength development and dispersion.

In the system of classification, we use the word fiberizing to describe that action which produces substantially whole and uninjured fibers from aggregates, the aggregates being considered such materials as raw chips, semichemically cooked chips, pulp mill rejects, or old paper.

The second classification, that of strength development, is most frequently measured by the development of the bursting



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resistance. But one may equally well use any other factor such as folding resistance, tearing strength, or tensile strength as a criterion. Or all of these strength factors may, for any evaluation, be plotted against freeness or drainage time. It is the general experience that, as compared with knife action refiners, the disk mill will develop a given bursting strength with less freeness drop and with less loss of tearing strength.

The "dispersing action" is doubtless dependent upon the enormous turbulence that can be generated in a liquid or semiliquid passing between the rapidly rotating disks. Soft shives and friable dirt can be dispersed so thoroughly that they are no longer visible in a sheet of paper. And "pitch" may be temporarily dispersed so that "pitch troubles" so frequently encountered in some of the northern pulp and paper operations may be profoundly reduced or eliminated. This dispersing action of disk mills may be better understood when it is considered that the principle of design of these refiners is substantially the same as that of certain types of successful colloid mills.

It has been the writer's experience that fiberizing is most effectively achieved with double revolving disk mills and in higher speed ranges of operation, that is from 900 to 1500 r.p.m., inclusive. The optimum average consistency of feed is about 8%, although with various materials, excellent results have been obtained with consistencies as low as 4% and as high as 15%.

Much the same conclusions apply to the operation of disk mills for their dispersing effect, except in this case the optimum consistency is from $3^1/_2$ to $4^1/_2$%.

In the case of strength development, however, the situation is definitely changed. Slower speeds of rotation are indicated, in the range of 400 to 750 r.p.m. Because of this situation, the single revolving disk mill is better adapted in most cases. Particularly because with the slow angular speed the "expelling" effect of the disks is seriously reduced, and the stock

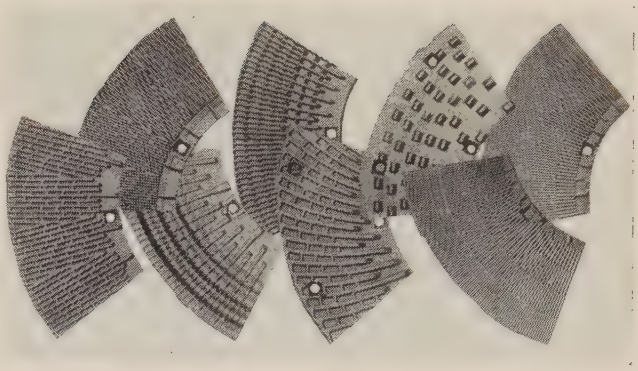

Fig. 3. Types of fiberizing plates

to be refined frequently has to be forced into the refiner under pressure, whereas gravity feed is almost invariably adequate for a double disk mill.

Another rule-of-thumb guide is that multistage or series refining is seldom advisable. (Multistage refining is taken as that procedure in which the entire discharge from a disk refiner is introduced into the second refiner. If the discharge from the first refiner is passed over a screen, and only the rejects introduced for a second pass, an entirely different situation is developed.) There are definite exceptions to this rule. One of them obtains when the refining power requirement is very high, and conversely, the feed to the pulper is very slow and hard to control accurately. Another exception is encountered when an adequate refining cannot be achieved in a single pass even though the plates are set "nipping" or at 0.000 clearance.

The general rule should also be amended when it is desired not only to fiberize semichemical chips, but to develop the strength of the pulp beyond the point that it would be de-

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veloped by a treatment which would achieve good fiberizing. In such cases, a two-pass operation is recommended, the first being a double disk treatment for fiberizing, and the second a strength development treatment in a single disk mill.

There are other exceptions to the conclusions that might be reached from the general rules enumerated above. For example, long stringy materials, such as flax straw, will tend to wind upon the spokes of a double disk mill, but they can be fed rather readily to a single disk mill, and so it is recommended that these stringy materials be processed through the latter type of mill, even though fiberizing is only desired, and it might be best to achieve in a double disk unit. Another effective solution of this same problem would comprise a two-stage operation, the first one as a breakdown processing through a single disk mill to prepare the stock so that it will be accepted by the double disk mill for most effective fiberizing.

In a paragraph above dealing with series refining, a sort of multistage refining procedure was mentioned, in which the screening or other classification followed each refining stage. This is really a sort of corollary to the question as to what proportion of the total stock should be refined in a single pass through the refiner.

In most installations to date, between 90 and 95% of the material entering a disk mill is refined in a single pass through it. The entire discharge from the refiner is then screened, either with a separate installation or by returning the refined material to the original screens, and the rejects only are given a second pass through the disk mill.

In addition, there are a number of installations in which 100% of the refining is done in a single pass, that is, the entire discharge from the disk mill is used, without screening, in the end product.

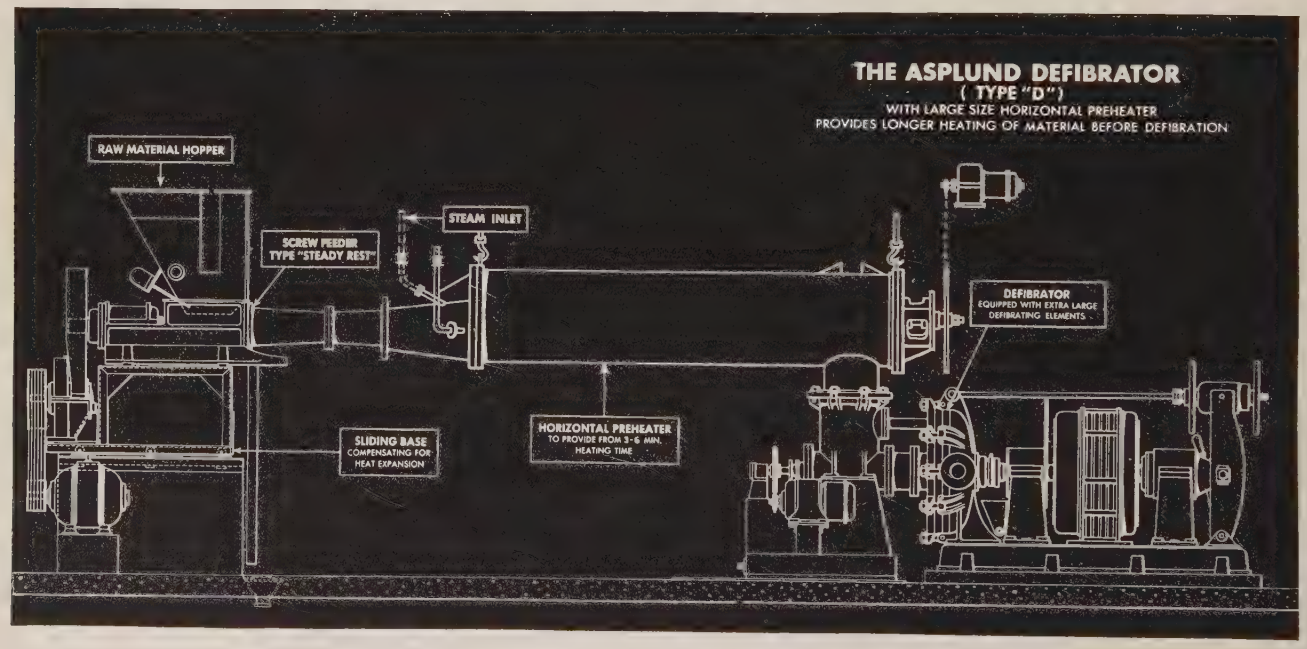
However, it would seem that the most uniform product would result from a system in which a smaller proportion of refining (say 60 or 75%) is accomplished in a single pass, this to be followed by screening, with the rejects from the rescreening operation being returned to the refiner for a second pass. This scheme would undoubtedly result in a refined product containing a smaller fraction of overrefined material, but would entail additional expense in screening or classifying, and would have to be studied for the particular installation and end product involved.

TYPICAL APPLICATIONS

As previously stated, there are a great many different types of semichemical pulping installations currently in use; in fact, it would be difficult to find two of them just alike. But for the most part, the sequence of operations and equipment in operating semichemical pulp mills is illustrated in Fig. 4. This diagram is to be taken as an illustrated flow sheet rather than a sectional view of pulp mill. In this scheme of operation, pulp is produced by three distinct steps: cooking, storing (with or without washing), and refining.

In this flow sheet, the use of rotary digesters is indicated. The cooked chips are dumped into a storage bin equipped with a turntable discharging mechanism. The refiners are provided with regulators, and likewise provision is made for a return of the excess chips to the storage bin. The flow sheet would be equally valid if vertical digesters were substituted for the rotaries, and if the cooked chips were blown into some form of washing equipment, as for example into diffusers.

Rotary digesters are much used in semichemical pulp production, and have a great deal of merit in this application. Because the cooked chips are dumped out of the digester, there are no discharging difficulties. Because of their rotary motion, they may be operated with a minimum volume of cooking liquor, and this results in a minimum of steam consumption. The long time required to blow the pressure off one of these globe rotary digesters is not a total loss; this long



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period of blowdown permits further steam economies by the use of a modestly priced heat exchanger. Because of their ability to empty themselves with a low liquor volume, rotary digesters are well adapted for the procedure involving preliminary impregnation, as described frequently in literature of the Forest Products Laboratory.

But the advantages of this type of digester are accompanied by a number of drawbacks. The size of unit is limited, they require a good deal of floor space per ton of production, generally more labor is involved, and a maintenance item involved due to the motion of the heavy equipment is appreciable.

Vertical digesters are also frequently employed in modern semichemical pulping installations. Generally speaking, such installations employ a higher liquor volume and so consume more steam per ton of product. Also, there are increased difficulties in blowing the digesters clean, although this operation, with proper attention, can be licked. The idea of a continuous cooker is very attractive to all pulp mill operators. Many of these devices have been proposed and some are currently in commercial operation. The use of a continuous digester will permit the elimination of a storage tank, thus feeding uniformly hot chips to the refiner. With this considerable range of choice in type and size of digesting apparatus, the particular equipment selected is generally determined by local economy and by the physical setup of an existing plant, especially when idle digesters are available in some previous or current pulp operation.

A similar diversity of acceptable equipment exists in the item of storage bins or tanks. Such storage should preferably be equipped with mechanism for the automatic and, as near as practicable, uniform discharge of the contents. Generally speaking, this rate of discharge of the storage chest should be slightly greater than the demand of the refiners, and the excess should return to the same bin.

The choice of the best-adapted storage tank will depend to some extent on whether, and to what extent, the chips should be washed prior to refining. Semichemically cooked chips from a neutral sulphite digester may be freed from 75 to 90% of the entrained chemicals by the simple procedure of flooding and draining the blown chips two or three times. In most chemical pulping operations, this would be considered as poor washing, but a great many of the semichemical mills are not provided with a chemical recovery, and so from the standpoint of chemical economy, thorough washing is not an item. However, the washing of semichemical pulp is becoming increasingly urgent, not only on account of over-all economy of production, but due to the stream pollution situation as well. When soda recovery is contemplated in a semichemical pulp mill, an installation of two-stage refining with intermediate washing is worthy of serious consideration.

Illustrated in Fig. 4 is a storage tank equipped with a turntable bottom discharge which is a very satisfactory type of storage in such cases where washing is not contemplated. Also used in semichemical pulp mills is a device borrowed from the tanning industry known as the leach-caster. This is quite satisfactory for crude washing but is rather cumbersome in operation and requires more attention to provide a uniform discharge than do some other types. A storage tank built along the lines of a Hofft fuel bin, one with a floor comprised mostly of controlled-speed worm conveyors, is an excellent device, both from the standpoint of crude washing and for uniform discharge with a minimum of attention.

Old diffusers from a kraft mill may also be used as can the more or less conventional blow tank currently employed in most kraft pulp mills which permit the digested chips to be pumped, after dilution, direct to the refiners.

The conveyors illustrated in Fig. 4 are of the ordinary heli-

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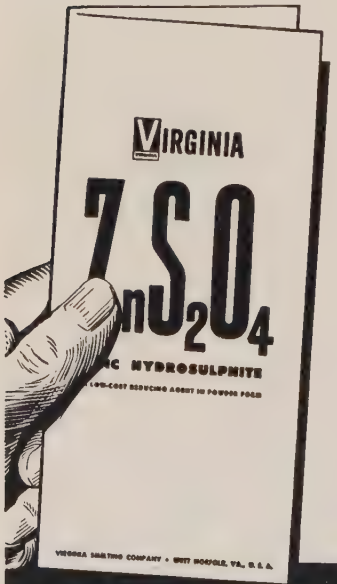

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cal screw-type, but any worthy type of conveyor may be used instead, and belts, drag chains, or bulk flow conveyors have all been employed successfully.

The refiners illustrated in Fig. 4 are of the double revolving disk type, but, as previously pointed out, other types may be used successfully if properly chosen.

The performance figures for the refiners involved in the flow sheet of Fig. 4 are subject to wide variations depending upon a number of variables. The main items among these variables are the kind of wood cooked, the type of cooking chemicals, the degree of cooking, the quality of pulp desired, and upon whether only a fiberizing job or a complete job of fiberizing and stock preparation is desired in a single operation.

The most common semichemical installation is one in which hardwood is digested to a yield of 70 to 75% and in which a complete job of fiberizing and stock preparation is accomplished in a single pass. In such an installation, the double disk mill, equipped with 400 brake horsepower in motors, will produce completely prepared pulp at the rate of about 30 tons per day. The capacity of refiners with 300, 500, and 600-hp. drives, is proportionate.

But, where fiberizing only is desired, and the prepared semichemical pumps is to have subsequent mechanical treatment in a separate stock preparation step, double disk mills with 300 hp. in motors are producing 75 tons per day each; this amounts to 4 hp.-days per ton.

More thorough cooking permits a further reduction in horsepower consumption; and conversely, less cooking, as in producing pulp of 80 to 85% yields, is accompanied by a higher power demand. This balance between the yield or degree of cooking on the one hand and power consumption on the other, is dictated by local economy considerations, which generally demand that not over 20 hp.-days per ton be used in the fiberizing operation.

In addition to sodium sulphite, a host of other cooking chemicals are employed in various semichemical pulping operations. These include kraft cooking liquor, caustic soda, lime, or lime and soda ash. Likewise, there are some applications of semichemical procedures to the softwoods and to other fibrous materials. But the variations involved in all of these special operations are too numerous to attempt to cover in this paper.

High-yield kraft production is frequently thought of as a separate, individual activity rather than one phase of semichemical pulping. This is easily understandable because of the specialized approach of high-yield kraft production; it is generally merely a development in conventional kraft mills achieved by changes in technique; the cooking chemicals are the same as those used in full cook kraft production. The field of application is, for the most part, in the range of 50 to 60% yield. And this operation is almost synonymous with "hot stock refining" or "prerefining."

It is easily demonstrated that, from the point of view of power consumption, fiberizing and strength development are most effectively accomplished on the raw cooked chips while they are still hot and in the presence of the alkaline black liquor. But there are elements other than that of power consumption that have to be taken into consideration in this type of activity. Practical drawbacks include the nuisance of much increased volumes of foam, troubles in evaporation incident to fines in the black liquor, and difficulties in thorough washing due to foam in the pulp, and due to the fact that the mechanical treatment may easily make the pulp too slow for proper washing unless the amount of "hot stock prerefining" is properly regulated with reference to the several factors.

In the lower yield ranges of high-yield kraft (that is, in the neighborhood of 50%), it is questionable whether the entire mass of pulp should be refined prior to washing. In this range, the stock in the blow tank is preponderantly comprised of well fiberized material containing knots and fiber bundles only modestly in excess of the amounts produced in the regu-

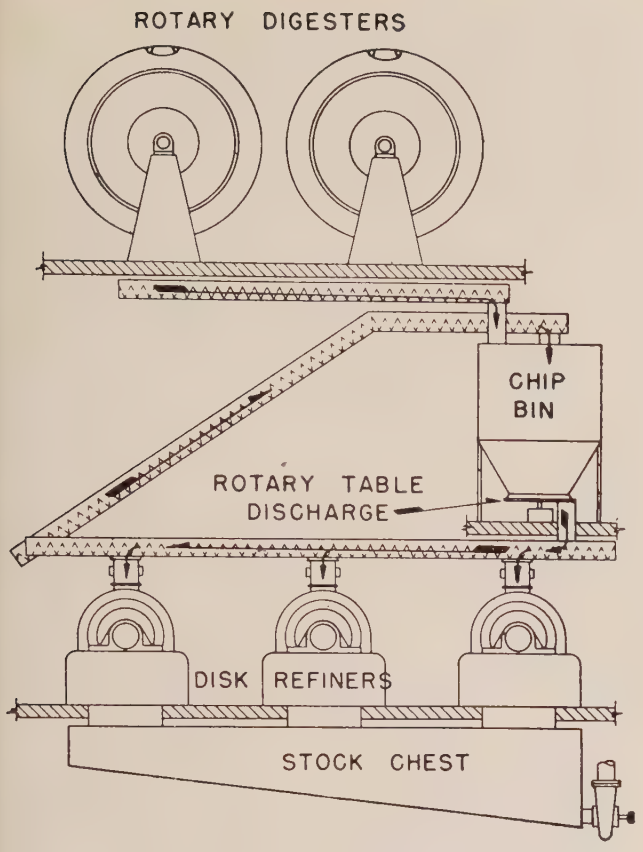


Fig. 4. Flow sheet of semichemical pulping system

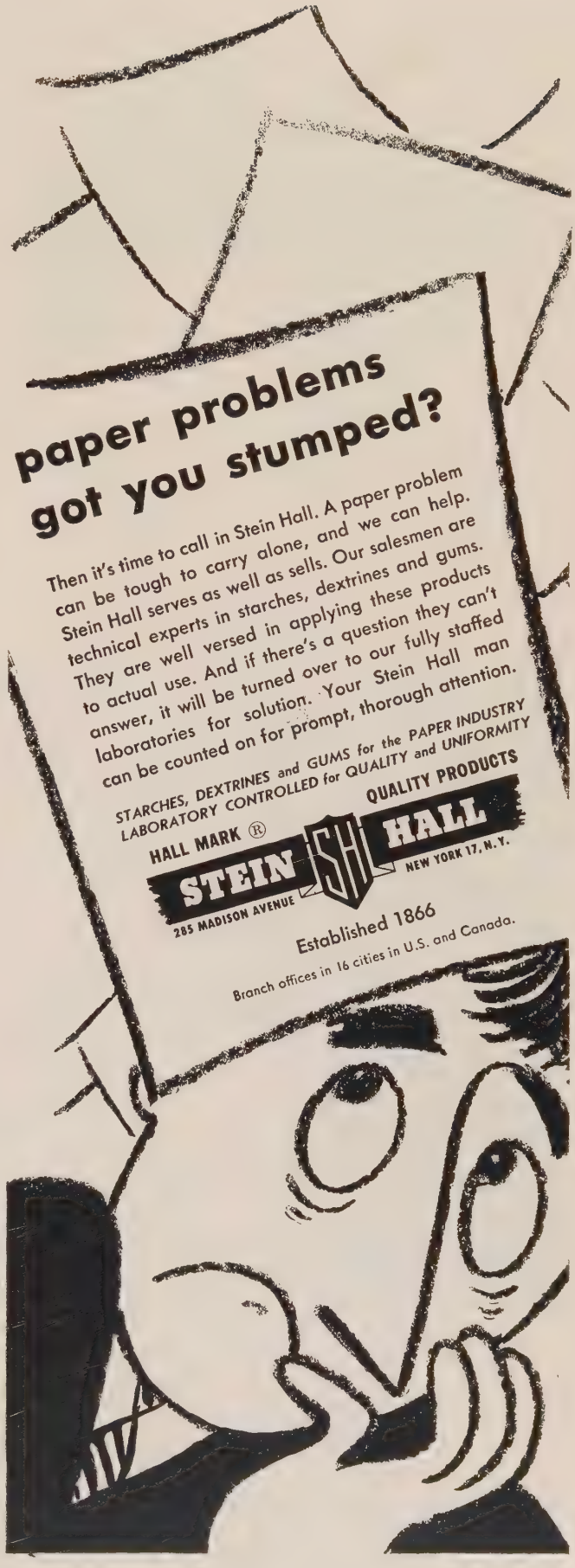
lar cooking operations. And the fiber produced in this range of yields is slowed down with very little power application and so likely to increase the washing difficulties out of proportion to the power benefits derived from the hot refining. In such cases, it is well to consider an installation in which the knots are removed from the brown stock immediately before the pulp goes to the washers, and in which the knots so removed are disk-mill hot refined to about the degree of the ordinary fine screen rejects. The refiner discharge is returned to the flow of stock either in the blow tank, or elsewhere in the flow ahead of the hot stock knotter screen.

By this procedure, the advantages of hot stock refining will be confined to that fraction which most needs it, the completely fiberized proportions of the pulp will not be slowed down at the risk of interfering with washing efficiency, but on the other hand, the washing will be improved due to the fact that knots have been eliminated from the stock going to the washer.

The point at which it will be advisable to refine the entire mass of pulp blown from the digester, rather than just the knots after removal from the good fiber prior to washing, is somewhat indefinite and variable according to the species of wood used and to other peculiarities of the individual mill. But a suggested rule of thumb is that, when the stock as pumped from the blow tank contains more than 15% of screening, the entire mass should be prerefined.

This general procedure would doubtless be theoretically applicable in all ranges of high kraft yields, but unfortunately the difficulties in screening after the proportion of rejects reaches 20 to 25% would be too much to justify a practical consideration. In such cases, the entire mass must be refined prior to washing.

When the high-yield cooking is regulated to produce yields in the range or 55 to 60% (accompanied by an excess of 15% screenings), the disk mill refining characteristics of the pulp have been so changed that the necessary power of fiberizing may be applied to the raw pulp without excessively slowing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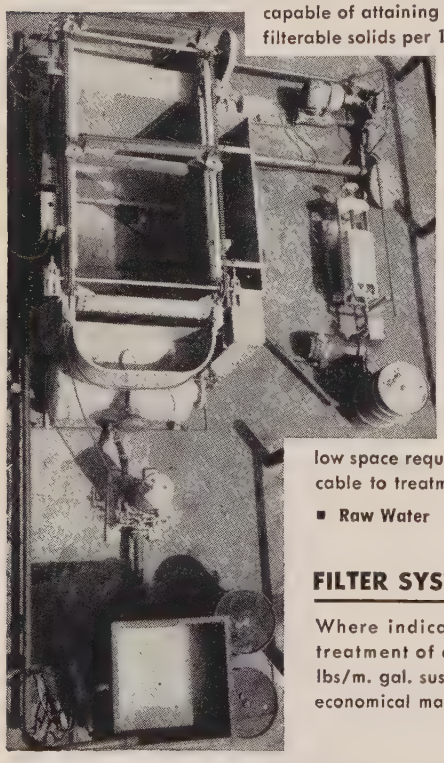

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it and so, at these higher yields, the hot prerefined pulp may be actually easier to wash than the regular stock.

High-yield sulphite practice follows the same general lines as that of the high-yield kraft but the procedures in general, are not so thoroughly perfected. For the most part, the proportion of screenings in high-yield sulphite is less than 15% and in all of the published accounts of commercially produced high-yield sulphite, the refining procedure is very much akin to that above described for that range of high-yield kraft in which the screenings are less than 15%. The notable difference is that, in sulphite, no hot stock prerefining has been attempted commercially.

Another group of procedures that can properly be classed as semichemical pulping, are those in which a fibrous material is reduced to a usable pulp by disk mill treatment following a digestion at atmospheric pressure. Of these, the only one known to have had a mill scale trial when applied to American woods, is that suggested by the Forest Products Laboratory and comprises a soaking of the chips in cold caustic soda solution prior to fiberizing in a double disk mill.

A sort of corollary to the above procedure is one in which the raw or presteamed chips are fed to a disk mill together with strong caustic soda, both in regulated quantities, and there given a preliminary breakdown treatment, reducing the chips to fiber bundles of about the diameter of toothpicks, these bundles being uniformly treated with the strong digesting liquor by the powerful mixing action of the disk mill. This mass of coarse fiber bundles may then be digested in a continuous apparatus at a temperature of approximately 200°F. for a period of an hour or two, and then, still continuously, be given its final fiberizing and strength developing refining in a second stage disk mill.

The above sketchily describes semichemical pulping procedures. While all those of current greatest importance are included, only a few of the potential applications of disk mill refining to the countless possible variations in semichemical pulp production are represented. And the type of product in which such disk-mill-refined semichemically cooked chips are employed embraces almost the entire range of paper and board qualities; ranging from the coarsest fibrous sheets represented by wallboard through grades such as saturating felt, wrapping paper, newsprint paper, container board, to highest quality bleached semichemical book and bond sheets.

Development of a System for Neutral Sulphite Pulping

Tany Agronin

In this particular discussion on neutral sulphite pulping, we are only considering the treatment of the pulp after digestion. It is immaterial in this discussion as to whether the pulp is prepared in rotaries, digesters, or in a combination of steeping tanks and rotaries.

Tany Agronin, Chief Engineer, Shartle Brothers Machine Co. Div., The Black-Clawson Co., Middletown, Ohio.

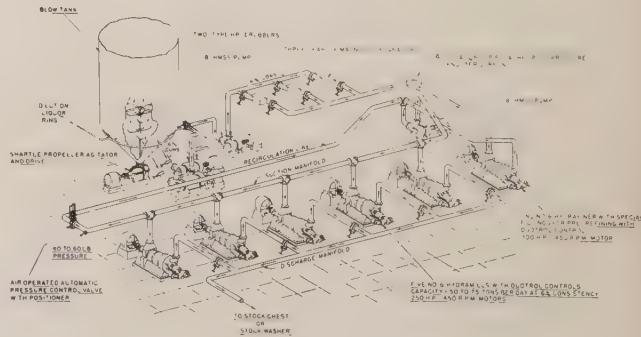

Fig. 1. 300-ton-per-day neutral sulphite hardwood system

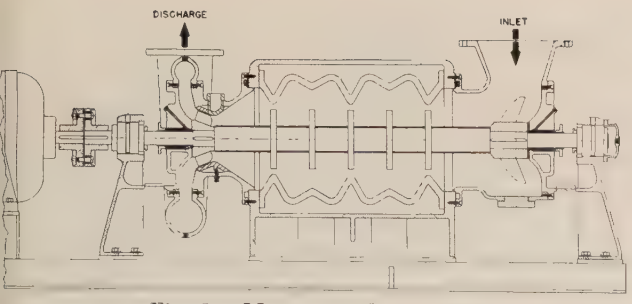

Fig. 2. Miami stock drubber

The basis of our particular design follows an installation which we have made in the southern kraft field on a hot stock refining system. Additional data on the development of this system have been done in our laboratory.

We have found that it is inefficient to attempt to do a complete pulping or refining in any single machine. Experience indicates that every type of machine is most efficient within a rather narrow range of operation. Thus, the most efficient system to do a complete refining and pulping job requires a number of machines, each of which is adapted to handle a specific part of the pulping and refining cycle.

In the system previously mentioned for hot stock refining, we were able to produce a satisfactory pulp at a lower horsepower per ton requirement than any similar system checked by the particular mill.

In a hot stock refining system, even at rather high permanganate numbers, the chips are broken down to the extent where we have had no difficulty in handling them in our No. 6 Hydrafiner; however, on the basis of new cooks for neutral sulphite pulping, we have found it desirable to include an additional piece of equipment known as the "Shartle Drubber."

The general layout of a system to produce 300 tons per day is shown on Fig. 1.

As you will note from this system, the stock from the digestion system flows into the Drubber which is actually a series of Hydrapulper rotors operating at a high speed in an enclosed casing as per Figs. 2 and 3, which breaks down the chips to a point where they can be handled by subsequent equipment. Two Drubbers are required to handle this tonnage.

Built into the Drubber is a mixed flow pump. The Drubber recirculates part of the stock to the blow tank and feeds the inlet of a stock pump which operates at about 15 pounds pressure which pumps the stock through a series of electric magnets, where the foreign material is removed, into the suction of a No. 6 Hydrafiner, Fig. 4.

The No. 6 Hydrafiner is equipped with a standard Hydrafiner filling which breaks down the broken chips into fiber bundles. This unit takes the complete tonnage, using a 300-hp., 450-r.p.m. motor.

The stock from the discharge of the No. 6 Hydrafiner is fed to a pump which builds up the pressure to approximately 50 pounds and pumps it through a series of No. 6 Hydramills.

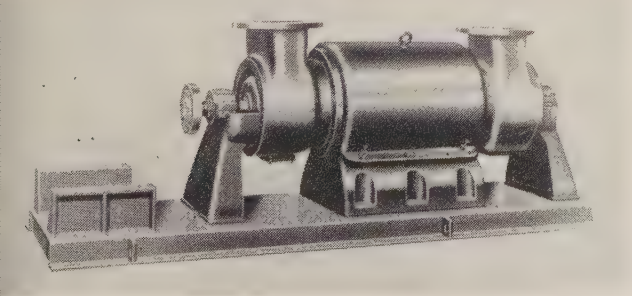

Fig. 3. Type "HS" Miami stock drubber

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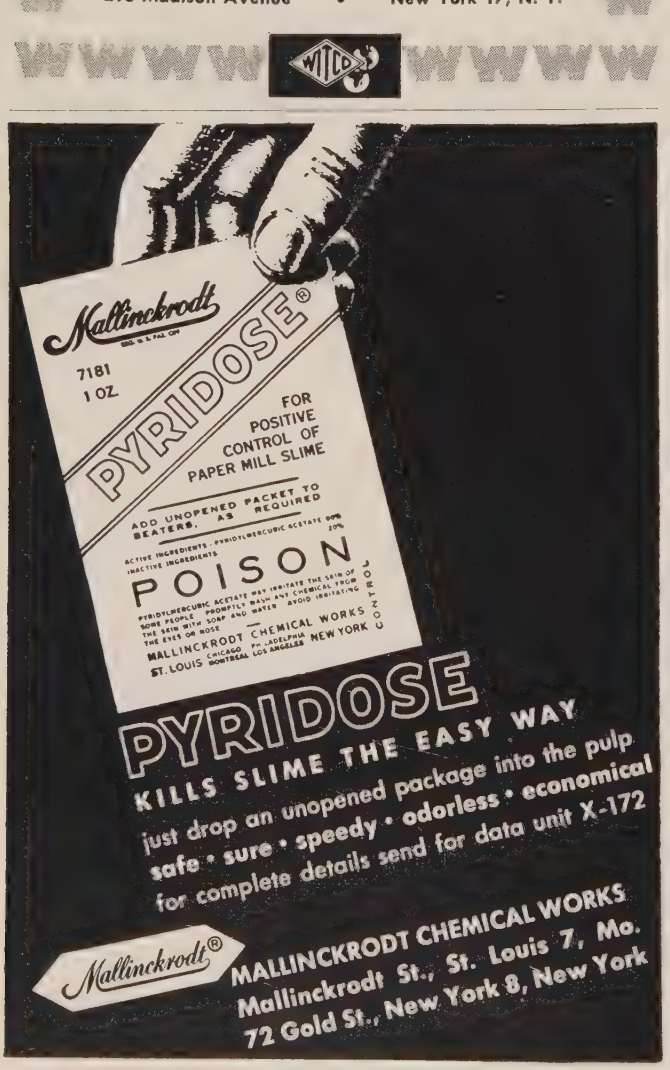
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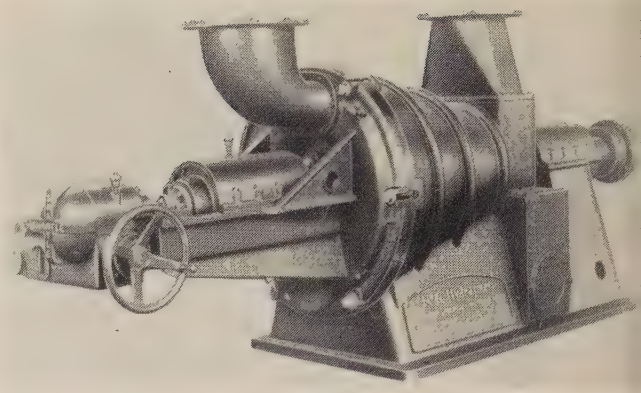

Fig. 4

These are conical refiners with special single-pass fillings which completely defiber the stock with the minimum of freeness loss. Each of these units is equipped with a 250-hp. motor the power requirement varying from 180 to 230 hp. depending upon the cook. The capacity of each unit varies from 50 to 75 tons.

For a 300-ton system, we have indicated five of the No. 6 Hydramills. The stock from these machines is completely defibered at a minimum freeness loss so that if washing is desired, the reduction in washing efficiency is very low.

One of the basic features of this system is that it is completely enclosed, thus eliminating the necessity of conveyors, intermediate chests, headboxes, etc., which add to the complexity of operation and do not produce any beneficial results.

Another feature of this system is that it can be set up with automatic control equipment so that a uniform product can be obtained. Both the No. 6 Hydrafiner and No. 6 Hydramill shown on the layout are equipped with the Shartle Duotrol Fig. 5, which is an automatic plug positioning device which can be operated through either ammeter or wattmeter control. All equipment can be operated from a centralized control panel.

The system as described is especially designed to provide a suitable pulp for board such as corrugating, etc. We believe, however, that with some minor changes it can be

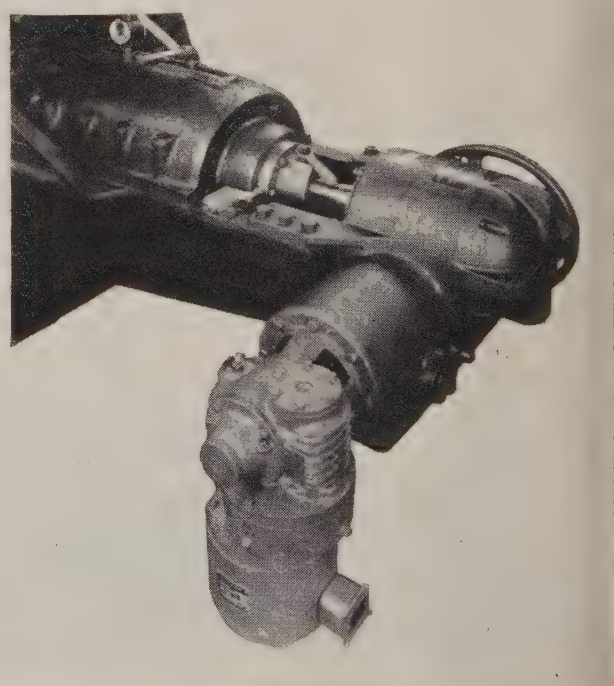

Fig. 5

leveloped for bleached hardwood pulps. While most of he development of hardwood pulping has been in the oard field, it has been our contention that the greatest pplication in the North for this particular type of equipment vould be to provide a bleachable pulp for the fine paper field.

The main feature which has to be added to this particular lesign is the installation of a pressure knotter screen at a point narked A shown on Fig. 1, in order to separate the knots and arger particles from the pulp suspension. These knots can e treated separately for other grades of paper.

We have found that the Drubber, while it will break down hips, does not have sufficient intensity to break down knots, herefore, knotter screens can be installed at this point to re-nove the knots, enabling the broken-down chips to pass hrough the screens. These can then be handled in the sys-em as described above, producing a pulp which is relatively lean in regard to knots and other foreign material. Addi-ional screening and bleaching are, of course, required to pro-duce a pulp for this application.

We have been working on a pressure knotter screen which, n our opinion, is satisfactory for the job. This is an adapta-ion of the screens which we are using in the waste paper field which are especially designed to handle coarse material.

We have found it advisable to operate all of these systems at consistencies of 6% or possibly higher. We have found that we can remove stock from the digesters at this consist-ency without any trouble if and providing we install propeller agitators in place of the usual paddle agitators. The pro-peller agitators are of special design and act to circulate the stock within the area of the bottom of the tank, producing a relatively constant consistency to the Drubbers as shown on Fig. 1. We have furnished a number of these agitators for both hot stock refining systems and neutral sulphite pulping systems with satisfactory results.

While this system does consist of a number of different items of equipment, it has been found so far that the over-all power requirements of the system are equivalent to, or slightly less, than similar installations of this type.

On the same basis we might add that all of the equipment shown on Fig. 1 is inexpensive, thus the over-all cost of the whole system is considerably less than that of other systems using less equipment. Maintenance-wise we have found that these refiner fillings give exceptionally good life, therefore, the operational cost of this system is in line.

Semichemical Pulping with Single Rotary Disk Refiners

Thaxter W. Small, Jr.

STATISTICS (*1*) available from the United States Department of Agriculture Forest Service place the timber volume in New England and New York State as 493 million cords at the beginning of 1945.

Of this amount 178 million cords were softwoods and 315 million cords were hardwoods.

Table I. Timber Volume[a] in New England and New York, Status Beginning of 1945 (Million Cords)

Softwoods		*Hardwoods*	
Spruce and fir	103	Birch, beech, and maple	248
White and Norway pine	40	Oak	30
Hemlock	28	Aspen	17
Other	7	Other	20
Total	178	Total	315

[a] Trees 5 inches diameter breast high and larger; does not include bark. Converting factors: softwood, 1 cord equals 78 cu. ft.; hardwoods, 1 cord equals 65 cu. ft.

More specifically the volume of spruce and fir totaled 103

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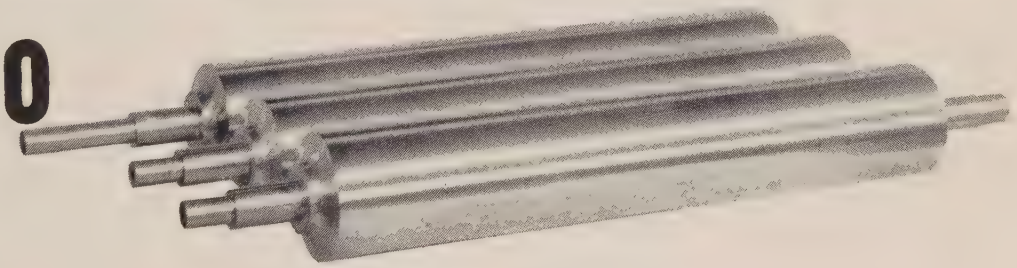

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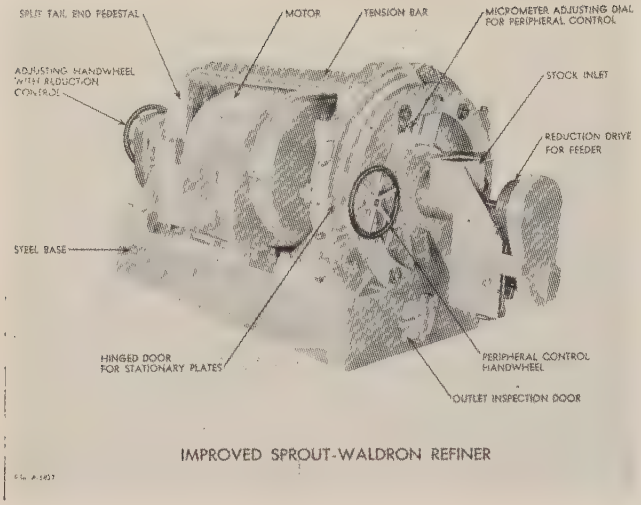

Fig. 1

million cords as compared with a total of 285 million cords for birch, beech, maple, oak, and aspen.

Still more interesting, however, is the fact that a comparison of the annual drain and growth status at the beginning of 1945 showed a surplus of 695 thousand cords for all softwoods and 4052 thousand cords for the hardwoods, 90% of which consisted of birch, beech, maple, oak, and aspen (*1*).

Table II. Comparison of Annual Drain and Growth, Status Beginning of 1945 (Thousand Cords)

Item	*Drain*	*Growth*[a]	*Surplus*
Softwoods	5,754	6,449	695
Hardwoods	8,040	12,092	4052
Total	13,794	18,541	4747

[a] Annual growth of all trees 5 inches diameter breast high and larger, including tops and limbs (tops only in softwoods) of saw-timber and total volume of trees reaching 5 inches diameter breast high each year. Bark not included.

The above figures definitely indicate that the future of the New England pulp and paper industry is largely dependent upon the development and utilization of these hardwoods as a source of pulp for direct manufacture into paper, for use as extenders, or for specialized application.

Whereas some New England mills are already blending in a small percentage of these hardwoods with their regular process, those contemplating future activity in this direction should give serious thought as to how you can most effectively, economically, and profitably process the hardwoods with regard to yield, quality, operational costs, etc.

The two most successful methods for pulping the hardwoods today are the neutral sulphite and neutral sulphate semichemical process. But a few years ago semichemical pulping was in the talking stage. According to information available to us, the estimated production of semichemical pulp in the United States for 1950 will total 605,000 tons. Of this tonnage over 50% was processed on Sprout Waldron refiners. In addition, we have already completed plans for handling an additional daily production of 1000 tons in the United States and one of these new installations incidentally will be located here in New Hampshire—the first in New England.

The popularity with which the industry has received the single rotary disk refiner for semichemical pulping is well founded.

In order that those present who have not had an opportunity to see one of these refiners may have a general understanding of its design, we would like to take this opportunity to briefly describe model 36-2 as used for semichemical pulping.

It will be observed from the figures that the refiner is of single runnerhead construction. The motor is integrally mounted on a heavy, 7-inch main drive shaft. The frame of the refiner will accommodate synchronous or induction-type motors upward to 450 hp. The motors are equipped with specially designed end bells and cooling fans. Standard operating speed is 900 r.p.m.

Engaging the main drive shaft on the rear or "tail end" of the refiner is a heavy bearing assembly of special design. Engaging the bearing housing is an adjusting screw which in turn is operated by a 9 to 1 ratio primary-secondary gear assembly and manually controlled handwheel. It is by this means that the main drive shaft and runnerhead (or) rotating disk is advanced or retracted. A dial micrometer graduated in one thousandths of an inch is located adjacent to the handwheel such that the operator will know his plate clearance or plate "gap" when the refiner is in operation.

The feed end or head end of the main drive shaft is equipped with a solid stainless 42-inch diameter runnerhead on which the refining segments and peripheral control segments are mounted. That portion of the shaft inside the casing is stainless inlaid. A stainless flinger is provided on the runnerhead for the purpose of uniformly distributing the stock entering over a 360° radius. Located in the front end pedestal between the runnerhead casing and the motor is a heavy spherical roller shaft bearing.

The stationary side of the refiner is of heavy ribbed, swinghead door construction. The refining plates are mounted on a heavy stainless liner seat, and the peripheral control segments are mounted on a heavy stainless ring encircling the refiner plates. The control ring is adjustable axially by means of a manually operated handwheel and peripheral control mechanism. It is also equipped with a dial micrometer graduated in one thousandths such that the operator will know the ring clearance or gap at all times.

The advantage of the control ring mechanism is that the

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operator can control or regulate the peripheral discharge of the stock from the refiner by restricting the clearance between the ring segments as compared with the refining segments, thus holding the stock back in the refining zone to accomplish the desired amount of work. Such a procedure results in building up a mat or fibrous layer between the refining plates and enables fiber-to-fiber refining other than metal-to-fiber refining characteristic of machines not provided with this unique feature. By means of this device Sprout Waldron refiners are capable of effecting a strong rubbing, rolling, and brushing-out action. We have been successful in overcoming the cutting, chopping tendency encountered from metal-to-fiber processing and in so doing obtained a long-fibered stock containing a minimum of "fines."

Through proper use of the control ring and the correct refiner plate combination we can produce a well-fibrillated stock suitable for direct use on the paper machine without screening or further processing (or) we can produce a strong, free, long-fibered stock suitable for additional refining through conventional-type stock preparation equipment further along in the system.

The Sprout Waldron refiner is adaptable to both fluid feed and dry feed. Whereas the figures illustrate the high consistency screw type feeder this can be replaced with an elbow or equivalent for fluid feed. Both types are being successfully used. This method of direct feeding permits uniform machine loading, uniform stock distribution, and, consequently, a uniform quality stock at maximum production.

It will be observed that the swinghead is supported at three points by adjusting screws and studs for purpose of tramming or aligning the refiner plates. An inspection port is provided adjacent to each adjusting screw such that a feeler gage can be inserted to check plate clearance.

Refiner plates normally used for semichemical pulping are of White Iron or NiHard composition. They are of high Brinell hardness, and render long service. The plates are "throw-away" type and scrapped upon replacement. A wide selection of refiner plates and control segments is available.

Excepting for the plates, all mechanical parts into which the stock and liquor come in contact are solid stainless or stainless lined.

Our present installations vary from three upward to as many as eleven refiners in an individual mill.

Our operations range from the production of pulp for corrugating and 9-point wherein unbarked or partially barked woods are used, intermediate grade pulps, and up through and including the highest quality pulps for semibleached and the fully bleached grades.

Yields vary dependent upon the pump requirements, type wood, method of wood preparation, etc., however, yields of 78 to 82% are being commercially realized daily.

Because Sprout Waldron refiners are capable of handling

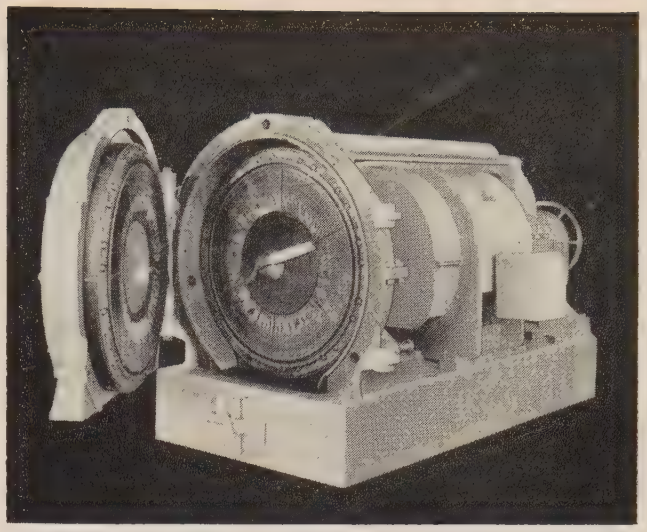

Fig. 2

fluid feed as well as the higher consistency deliquored chips, many interesting methods of processing have resulted.

In the earlier semchemical pulp mills rotary digesters are commonly used. The cooked chips are discharged into a leach caster or equivalent located directly below and the excess liquor drained off. The chips are then discharged from the leach casters at a controlled rate of feed and conveyed to the refiners for a one-pass operation. The refined stock goes directly to the paper mill. In the manufacture of corrugating and 9-point the stock is not screened and is subjected to little or no additional refining.

It was later discovered that better fibrillation at lower power expenditure resulted when processing the chips hot and in the presence of the cooking liquor. The trend today is definitely in this direction.

In our more recent installations vertical digesters are being used and the refiners arranged in series or in parallel, preferably the former.

A typical arrangement is one whereby the chips are pumped from the blow tank in the presence of the cooking liquor at 7 to 8% consistency and 200 to 210°F. into a main header supplying the primary Sprout Waldrons. The primary refined stock goes over vacuum washers for liquor removal then mixed with white water for secondary refining.

Whereas washing is accomplished between the primary and secondary stage in the above instance, in another installation washing is accomplished following the secondary stage.

In some of the other installations the practice is to pump the hot fluid chips from the blow tank to a simply constructed perforated plate drag-type drainer conveyor located directly over the refiners such that the hot thickened chips discharge

The DRAPER Felt
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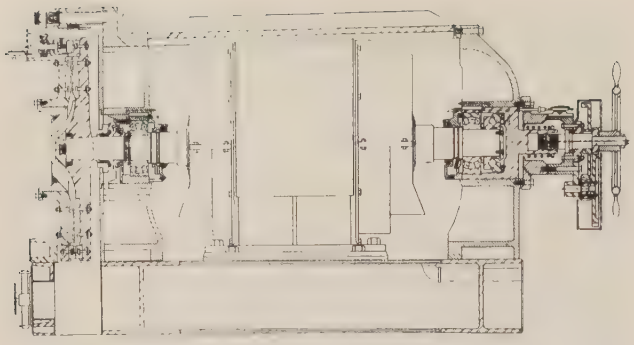

Fig. 3

directly into the refiner inlet screw. Some mills are using a one-pass operation, others a two-pass operation with additional vacuum washing between the first and second pass and still another uses a two-pass operation with no additional washing—the degree of washing is dependent on the end product.

In addition to the above there are other specialized methods of stock pretreatment and handling direct toward the processing of the highest quality pulps for bleaching.

I recently attended a meeting of the Georgia-Florida Pulp and Paper Society. In discussing "Trends of the Industry" the principal speaker and a leading authority in the southern pulp and paper industry remarked that the day was close at hand when gumwood, now commmonly used by the southern mills for unbleached semichemical pulping, would be considered too valuable a wood to use excepting for the manufacture of semichemical bleached pulps.

There is little doubt in that the same method of reasoning applies to the New England pulp and paper industry insofar as birch, beech, maple, aspen, and some of the other hardwoods are concerned.

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Empire State

The Empire State Section held its annual meeting at Whiteface Inn, Lake Placid, N. Y., on June 27–30, 1951. About 300 individuals attended.

A large proportion of the group arrived on Wednesday afternoon, June 27, in time for the get-together party. Following dinner, motion pictures were shown of woods operations and fire-fighting techniques.

The technical program on Thursday, June 28, was devoted to the pulpwood supply situation in New York State. Irving V. Earle, Jr., of the Upson Co., Lockport, N. Y., presided as chairman.

The first speaker was G. A. Pesez, Assistant Resident Manager of Woodlands for the International Paper Co., Glens Falls, N. Y., who discussed "Industry's Role as Related to New York State's Pulpwood Supply." (Mr. Pesez' paper is published in this issue, page 20 A.) He stated, in substance, that New York State mills obtain nearly two thirds of their pulpwood from other states and Canada. This is a very unsatisfactory situation, and it is becoming worse because wood from outside the state probably will be harder to obtain in the future. There are in New York about 11,000,000 acres of commercial forests, but under present conditions it is doubtful that any company is growing as much wood annually on its own holdings as required to maintain its mill in full production.

A logical step would be for mills to acquire more forest land, but there are several deterrents to such a course. Additional planting of suitable species would be another approach. More intensive use of hardwoods, and by-products such as veneer cores and sawmill slabs, would be highly desirable. Various problems and possibilities in this connection are discussed, including mechanical procedures, chemical debarking, etc.

The combined efforts and research of pulp manufacturers, the State Conservation Department, and other agencies should go far to reduce the growing dependency on outside sources of pulpwood supply.

The second speaker was J. Victor Skiff, Deputy Commissioner, State of New York Conservation Department, Albany, N. Y. Mr. Skiff's talk begins on page 24 A.

The final speaker at this session was Fred W. O'Neil, Associate Professor of Pulp and Paper Manufacture, State University of New York, College of Forestry, Syracuse, N. Y. Mr. O'Neil's paper will be found on page 26 A.

The afternoon of Thursday was devoted to trapshooting competition under the direction of Ivar Ekholm of the National Aniline Division, a ladies golf tournament in charge of Mrs. R. M. Drummond, and a boat trip on Lake Placid. Following dinner each evening there was a dance held at the Boat House.

The technical program on Friday morning, June 29, was held under the chairmanship of Foster P. Doane, Jr., of the Sandy Hill Iron and Brass Works, Hudson Falls, N. Y. With the exception of the paper by Messrs. Darmstadt and Richter, the papers are published in full in this issue of *Tappi*, pages 110 A to 119 A.

Philips S. Bolton, Research and Technical Director of Robert Gair Co., Uncasville, Conn., discussed "Trends in the Paperboard Industry." In this paper he discussed the problems relative to the collection and utilization of waste paper for container manufacture. The important factors in the design and development of corrugated and solid fiber boxes were mentioned, with special reference to V-board.

W. J. Darmstadt and F. H. Richter of the Babcock & Wilcox Co., New York, N. Y., discussed "Some Economic Aspects of Burning Sulphite Waste Liquor."

The final speaker was Clinton K. Royce, Head of the Packaging Section, Office of Naval Material, Navy Department, Washington, D. C. Mr. Royce talked on "The Impact of Defense Requirements on the Pulp and Paper Industry."

On Friday afternoon a driving downpour of rain did not dampen (much) the participation in the men's golf tournament. The ladies remained indoors and played bridge and canasta. A scheduled trip to Whiteface Mountain and the North Pole had to be called off because of heavy fog and rain on the high mountain roads. Many made good use of the free afternoon to catch up on sleep lost during the two preceding nights.

Harold Spector of the St. Regis Paper Co., Watertown, N. Y., presided at the technical session held on Saturday morning, June 30. These papers are also published in this issue.

The first speaker was Horace A. Spencer, Director of Research of Knowlton Bros., Watertown, N. Y., who expressed "A Few Thoughts on Stream Pollution."

The second speaker was Lou Engelhart of the Products Development Laboratory, International Printing Ink Division, Interchemical Corp., Elizabeth, N. J., who presented a paper on "Printing Ink and Equipment Developments and Their Effect on Paper Requirements."

The final paper was presented by E. C. Jahn, Director of Research and Professor of Forest Chemistry, State University of New York, College of Forestry, Syracuse, N. Y. Dr. Jahn talked on "Reciprocal Paper-Plastics Developments" (see page 8 A). His talk is briefly outlined below:

The remarkable growth in the development of many new types of plastics during the past twenty years is reflected in new com-

binations of plastics with paper. Methods of addition of plastics to paper are described; these include tub sizing, saturation, beater addition, coating, and film lamination.

A survey of paper-plastics combinations and their uses covers the following types: sized papers, wet-strength papers, flexible boards, grease- and moisture-resistant papers, coated papers, laminated papers, laminated structural products, and molded pulp products. Many new developments are predicted for the near future.

Henry J. Perry, *Paper Trade Journal*, New York, N. Y., was general chairman of the meeting. Mr. Perry was completing his term of office as Chairman of the Empire State Section. The Section is made up of five districts, each holding frequent meetings from September to June at New York City, Glens Falls, Syracuse, Watertown, and Niagara Falls.

Each district has its own organization of chairman, secretary, committees, etc. Once each year, in June, all five districts hold a combined conclave as the Empire State Section Annual Meeting. The responsibility for organizing and handling the annual meeting is rotated by district organization. This year the responsibility fell to the Metropolitan District, which holds its regular monthly meetings at Fraunces Tavern in New York City. It is the prerogative of the District to designate the time and place of the annual meeting of the Section in accordance with the Section's Bylaws. Whiteface Inn on Lake Placid was chosen as the site because of its central location and many other desirable features.

Chester G. Landes of the American Cyanamid Co., Stamford, Conn., did an outstanding job as Chairman of the Technical Program. Mr. Landes also gave out the attendance prizes at the sessions. To qualify, an individual had to arrive on time and remain until the session was completed. In the drawing for prizes Mr. Landes rather bountifully distributed several television sets following each technical session.

The Social Events Chairman was K. E. Youngchild of the American Cyanamid Co., New York, N. Y., an excellent choice. If he had not been chairman, he certainly would have been awarded the first prize at the Costume Ball.

Paul Haggerty of George La Monte & Son, Nutley, N. J., handled the premeeting publicity and Jack F. Butterworth of Socony-Vacuum Oil Co., New York, N. Y., took care of reservations and finances. The Mill Visits Chairman was Wm. R. Willets of Titanium Pigment Co., New York, N. Y. Since there were no mills near Lake Placid, arrangements were made to enable individuals to visit plants enroute to the meeting. These included the Finch, Pruyn Co., Glens Falls, J. &. J. Rogers Co., Au Sable Forks, International Paper Co., at Palmer, and Ticonderoga, the "Big Blow Down" of trees due to the November hurricane along Highway 10, and the titanium mine at Tahawus, N. Y.

At the business meeting of the Section held on June 28, Ralph N. Prince of American Cyanamid Co., New York, N. Y., Secretary of the Section, reported the election of officers for the Section and the Districts:

Chairman: Joseph S. Reichert, E. I. du Pont de Nemours and Co., Inc., Niagara Falls, N. Y.
Chairman-Elect: Foster P. Doane, Jr., Sandy Hill Iron and Brass Works, Hudson Falls, N. Y.
Secretary-Treasurer: Ralph N. Prince, American Cyanamid Co., Castleton, N. Y.
National Executive Committee Representative: Ralph W. Kumler, American Cyanamid Co., New York, N. Y.

Executive Committee

Officers
J. F. Butterworth, Socony-Vacuum Oil Co., New York, N. Y.
H. D. Cook, Sweet Bros. Paper Mfg. Co., Inc., Phoenix, N. Y.
I. V. Earle, Jr., Upson Co., Lockport, N. Y.
M. J. Landberge, General Dyestuff Corp., New York, N. Y.
H. H. Lavery, International Paper Co., Palmer, N. Y.
C. E. Libby, N. Y. State College of Forestry, Syracuse, N. Y.
D. C. Mather, Carthage Paper Makers, Carthage, N. Y.
J. W. Morrow, Newton Falls Paper Mills, Newton Falls, N. Y.
R. D. Moynihan, Finch, Pruyn & Co., Inc., Glens Falls, N. Y.
H. Spector, St. Regis Paper Co., Watertown, N. Y.
G. K. Storin, Niagara Alkali Co., Niagara Falls, N. Y.
W. R. Willets, Titanium Pigment Co., 99 Hudson St., New York 13, N. Y.

Central District Officers

Chairman: C. E. Libby, N. Y. State College of Forestry, Syracuse, N. Y.
Vice-Chairman: H. D. Cook, Sweet Bros. Paper Mfg. Co., Inc., Phoenix, N. Y.
Secretary-Treasurer: Barbara H. Wertley, Solvay Process Co., Syracuse, N. Y.

Eastern District Officers

Chairman: H. H. Lavery, International Paper Co., Palmer N. Y.
Vice-Chairman: R. E. March, Marinette Paper Co., Fort Edward, N. Y.
Secretary-Treasurer: K. L. Seeber, Sandy Hill Iron and Brass Works, Hudson Falls, N. Y.

Metropolitan District Officers

Chairman: W. R. Willets, Titanium Pigment Co., New York, N. Y.
Vice-Chairman: R. W. Kumler, American Cyanamid Co., New York, N. Y.
Secretary-Treasurer: J. F. Butterworth, Socony-Vacuum Oil Co., New York, N. Y.

Northern District Officers

Chairman: J. W. Morrow, Newton Falls Paper Mill, Newton Falls, N. Y.
Vice-Chairman: R. A. Premo, Gould Paper Co., Lyons Falls, N. Y.
Secretary: T. E. English, E. I. du Pont de Nemours and Co., Inc., Watertown, N. Y.
Treasurer: J. H. Treadwell, Treadwell Supply Co., Watertown, N. Y.

Western District Officers

Chairman: I. V. Earle, Upson Co., Lockport, N. Y.
Vice-Chairman: G. K. Storin, Niagara Alkali Co., Niagara Falls, N. Y.
Secretary: F. P. Heil, Lockport Felt Co., Lockport, N. Y.

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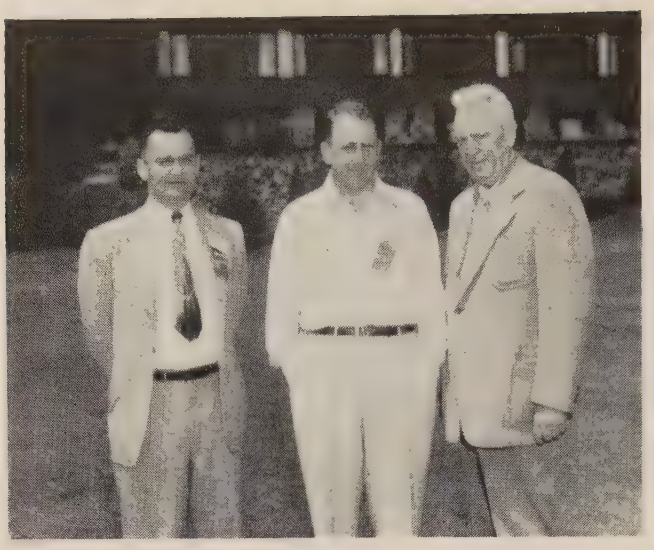

R. N. Prince, American Cyanamid Co., Secretary-Treasurer; H. J. Perry, Paper Trade Journal, retiring Chairman; and J. S. Reichert, E. I. du Pont de Nemours & Co., Inc., Chairman of the Empire State Section of TAPPI

Treasurer: J. J. Forsythe, International Paper Co., Niagara Falls, N. Y.

Mr. Prince's report of the Empire State Section for the past year follows:

"The Empire State Section of TAPPI closed a very active year with its annual meeting at Whiteface Inn, Lake Placid, N. Y., on June 27–30, 1951.

"During the 1950–51 season, 29 meetings, exclusive of the annual meeting, were held in the five districts. It is estimated that 1800 to 2000 was the total attendance for the year. There were more panel type meetings than in previous years. In some districts, where operating personnel predominate, a start was made toward greater participation by the younger men in the industry.

"The first Annual Senior Dinner, under the sponsorship of Empire State Section, for the graduating students at the New York State College of Forestry was held on May 18, 1951, at Drumlins Country Club, Syracuse, N. Y. At the dinner, reactivation of the Central District was announced. It is expected that six to eight meetings will be held by this district during 1951–52.

"Membership in the Section increased to 441. Three members passed away.

"Regulations were drafted to govern a Junior Award of $100 to be made available annually. It is expected that competition for this prize will begin during 1951–52.

"The financial condition of the Section is:

Cash on hand 8/19/50		$ 942.87
INCOME:		
Rebate from National TAPPI		396.00
Dues from 313 National TAPPI members		469.50
Dues from 128 Non-National TAPPI members		384.00
Annual Meeting, Whiteface Inn		439.62
1951–52 dues received		24.00
Total		$2655.99
EXPENSES:		
Central District	$0.00	
Eastern District	122.60	
Metropolitan District	168.19	
Northern District	201.35	
Western District	73.50	
Chairman and Executive Committee	48.75	
Senior Dinner	142.20	
Election	29.00	
Secretary's Office:		
Stamps and envelopes	$56.70	
Stationery	69.25	
Stenographic	66.70	
Telephone	25.73	
Bank charges and Deposit box	16.75	
Surety Bond	5.00	
	240.13	
Total		$1025.72
Cash on hand 7/9/51		$1630.27
Other assets: Two Series F Bonds, 9/1/55 maturity. Present value		855.00
TOTAL ASSETS:		$2485.27

Note: Cash on hand includes $48.50 held by Central District, $340.31 held by Metropolitan District, and $87.40 held by Eastern District."

RALPH N. PRINCE, *Secretary-Treasurer*

Trends in the Paperboard Industry

Philip S. Bolton

WHEN I was asked in February to give a paper having to do with the board industry, I was told that the general subject of the meeting was "Changing Trends in the Paper Industry in New York State." Without giving enough thought to the obvious fact that this indicated some gift of prophecy, I accepted. My lack of qualification as a prophet is proved by the fact that I have found anything I have written since February as a forecast has been completely wrong inside of 10 days. The latest 10-day period is up as of today so that my best advice is that you place no bets on my crystal-gazing efforts.

Some months ago I visited Grand Rapids and had my Sunday dinner in a highly recommended local restaurant. The dinner was excellent. When it came time to select dessert, I found in the list "the best apple pie in the world." Now I come from the State of Maine where, as you know, apple pie is considered a staple portion of all meals including breakfast, so I ordered the apple pie. It was good, but they had taken in too much territory.

In order not to make a similar mistake, I am going to limit my remarks to that portion of the board industry with which I have some familiarity and start by omitting fourdrinier kraft board which, while it does represent a large portion of container board tonnage, is more allied with papermaking proper. It is a virgin sheet. The board I am going to talk about is distinctly not a virgin sheet and its manufacture sometimes seems to me to be very improper papermaking.

The best approach to this subject of "Trends" is to start with the raw materials. Our raw material is waste paper. By waste paper we mean that it was originally made from pulp, put to some end use, served the purpose for which it was made, and then discarded. The collection and grading of this discarded waste paper have grown to be much more of an industry than is generally appreciated. In 1950 some 7,900,000 tons of waste paper was collected, graded, and sold to the paper and board mills. The collection rate so far in 1951 has been basis of 9,000,000 tons for the year. Even in these times, 9,000,000, be it tons or dollars, is a good round figure. Perhaps I can best bring home what it means by saying that if we assume that one ton of pulp can be produced from one cord of wood and that natural wood reproduction is at the rate of $^1/_2$ cord per acre per year, the area required to produce this tonnage would be 18,000,000 acres, or 28,000 square miles, or 60% of the area of New York State. About 10% of this collection will come out of the New York City area. If you don't like the 1 cord per ton and the $^1/_2$ cord per acre, you

PHILIP S. BOLTON, Research and Technical Director, Robert Gair Co., Uncasville, Conn.

can use your own figures and still come out with a lot of square miles.

Collecting this waste paper is, I repeat, an industry of substantial size, both in tonnage and in dollar value. It has its own peculiarities. Much of it is done with what might be called substandard labor. A loose ton is bulky. Sorting before baling is difficult and on a tonnage basis, expensive. It is subject to violent fluctuations in price. I might say here that the collection is entirely dependent on the immediate demand for consumption as its bulk, even after baling, makes inventory storage, except in limited quantities, impossible. Some of you are still undoubtedly paying more for certain of the higher grades than the market price for their equivalent in virgin pulp. You also have found that price fails miserably as a measure of quality. In fact, the higher the price for a given grade, the lower the quality is likely to be. This extends all the way from the top grades, such as white envelope cuttings, down to the bottom, so-called mixed paper.

That is a name that fits. Mixed paper is basically some paper mixed with about anything else you can dream of. I am not prepared to vouch for it, but I'm told that in one case a bale of mixed, when opened, contained a full-sized barber chair. I do know that negotiable bonds and diamond rings have been found.

Three months ago I wrote that the trend in waste paper was up in price and down in quality. Today that has been somewhat revised so far as the lower grades are concerned.

There are three principal end uses for paperboard: (1) container board—solid fiber and corrugated, (2) folding cartons, and (3) set-up boxes.

Again to avoid taking in too much territory, I am passing over the last named with the comment that, as was true during World War II, there is an increasing demand for set-up boxes as substitutes for other types of packages with which they do not ordinarily compete.

This is equally true of the folding carton. Shortages of tin, lead, and aluminum always develop a demand for substitutes for containers made of these materials. The carton maker is often asked to produce a package for materials where the tin can is a more satisfactory package. Clever designing of folding cartons to produce a suitable package, however, very often leads to new fields where paperboard has not previously been considered. In this way the market is expanded. When properly designed, the folding carton does an excellent job. Without proper consideration of content and end use, some of these substitutions are dismal failures. Again as to trends in the folding carton field, they seem to be in the direction of an expanding use as an inexpensive—and with modern printing—a decorative package. The defense effort has some bearing on this portion of the industry as it is calling for some 20,000,000 cartons per month largely for ration packing.

This brings us back to no. 1 on the list—containers—both corrugated and solid fiber. Due to its light weight and great strength, the corrugated container has enjoyed a phenomenal growth, from $3^2/_3$ million tons in 1941 to $5^1/_3$ million tons in 1950. As in the folding carton field, design of the package for use requirements is very much a part of the picture. It is not safe to assume that because a simple corrugated box is strong enough to assure complete protection for a dozen cans of tomatoes from the cannery to the corner grocery that a similar case will protect a pair of blankets weighing much less. In one case the contents help to support a stacking load, in the other, the case alone must do it. With proper designing for the use requirements the corrugated case is an excellent package for domestic shipments.

During the first part of World War II, because of the necessity of getting food and clothing overseas without delay, great quantities were shipped in the standard domestic corrugated box. At the bases behind the lines warehouses were a minus quantity and the cases were stacked out-of-doors in the weather. The failures were many.

The armed forces called on the board industry for an answer—and in a hurry. This brings up a story of cooperative effort for which the industry has reason to be proud.

C. G. Landes, American Cyanamid Co.; G. A. Pesez, International Paper Co.; F. W. O'Neil, College of Forestry, State University of New York; and I. V. Earle, The Upson Co.

The producers of containers were called together and the Fibre Box Association organized. Within this group a technical committee was set up. Everyone contributed his know-how to the problem and specifications for the solid fiberboard and designs for the package were worked out. How well this was done is attested by the fact with the outbreak of the Korean situation and the present rearmament program, these specifications, with only minor changes, are in force today.

At the start, no one thought it possible to produce a weatherproof corrugated container, and as a matter of fact, 30 years of peace time had failed to produce either solid fiber or corrugated boxes which would protect contents against the weather. This was partly due to cost considerations which no longer applied during war. The first result of the industry-wide effort was the production of a solid fiberboard which would withstand $2^1/_2$ hours of submersion in water with the loss of only one half of its original burst test. This board failed under the tropic conditions on the Pacific Islands and the specification was raised from $2^1/_2$ to 24 hours. This was V-board. V-board is not waterproof, but a case made from it will not disintegrate during a 24-hour test in the surf.

Since the war, work has continued on the development of a weatherproof corrugated case and such a case is now produced and used by the armed forces where the requirements are not quite so stringent. Where weight is of importance, as in air transportation, this case has obvious advantages. There is also a saving in fiber used per carton.

At the present time the industry is operating at the rate of 25,000 tons per month on these weatherproof grades. This is in excess of the government requirements for the balance of 1951. From August 6 to the end of the year some 70,000 tons will be required from a total of 137,000 tons for the year. This would indicate some slackening in demand between now and the beginning of 1952. In the over-all board picture, to quote from the figures given by C. C. Merrifield of the Econometric Institute, in his report to the Fibre Box Association in April of this year, the shipment of containers in relation to demand has been 112.9% and his forecast is a declining demand for the last two quarters of from 77 million to 74 million square feet. This decline is not large percentage-wise and the demand forecast for the first quarter

of 1952 is still considerably greater than actual production in the first quarter of 1951.

So far as the container board industry is concerned one

Clinton K. Royce, Navy Dept.; P. S. Bolton, Robert Gair Co., Foster P. Doane, Jr., Sandy Hill Iron & Brass Works; W. J. Darmstadt and F. H. Richter, Babcock & Wilcox Co.

hurdle which we had at the start of World War II has been removed. The armed forces are today very much aware that proper packaging is essential. Mr. Royce who follows me, will, undoubtedly, tell you of many improvements in V-boxes wanted, such as rodent and insect repellency, resistance to extreme temperature changes, etc. These will probably be improvements on the present V-box rather than a new container development. Someone has said that the package is the last thing thought of by the shipper and the first thing seen by the customer, but with the armed forces it is now one of the first things considered and has top-ranking importance.

Impact of Defense Requirements in the Pulp and Paper Industry

Clinton K. Royce

I ALWAYS welcome an opportunity to meet with people in industry for I am still an industrialist at heart—and when that contact is one which brings me to a conference of people interested in fields akin to packaging, it is doubly welcome—for my business is packaging.

These are indeed trying times for you people in the paper industry. I have been asked to discuss the impact of the defense program upon your industry and believe me, that request is no small order.

Military packaging is going to take a large share of your products in which the Government is most interested. Obviously you make many things for the Government other than packaging materials. But right now the availability, or more appropriately perhaps, the lack of availability of these packaging materials is causing us grave concern.

Any discussion of military packaging must of necessity begin with a full and complete analysis of the military concept of packaging; include information as to the present and contemplated military packaging organization; recognize our shortcomings of the last war; show how we propose to eliminate those as well as anticipated new ones; and point up the need for the development of new materials, techniques and yes, even new concepts.

CLINTON K. ROYCE, Head, Packaging Section, Production Policy Div., Office of Naval Material, Department of the Navy, Washington, D. C.

In the Department of Defense we regard packaging as the science of "Preparation of Material for Shipment." If some among you want to be technical you may add "and Storage" to that. But the really important word in that definition is "preparation." Thus we see that the term "packaging" as we use it in the military services covers the cleaning and preservation of material and its wrapping or cartoning in the unit of issue; it includes all the necessary cushioning, blocking, and bracing to protect the material from damage resulting from shock; it embraces the design and engineering of shipping containers; it includes the match-marking of parts, assemblies, and equipment and the marking of containers for shipment. In short, it covers the "preparation of material for shipment."

World War II presented problems in material logistics which our armed forces had never before been called upon to meet. Not the least of these were those pertaining to the movement of vast quantities of material by all manner of means, over great distances, with an absolute minimum of personnel, transport, and time.

It is interesting to note how many of these logistics problems find their solutions in the adequate packaging of military stores. The Navy's secret weapon of World War II was our supply system—that system of mobile fleet support which enabled the fleet to deliver those knockout blows to the Japs during the final year of the war in the Pacific with such terrific force and with such frequency and regularity. But it is obvious that no carrier launched a plane, no submarine let go a torpedo, and no bluejacket loaded a gun without the support of material which was preserved, packaged, packed, and identified so as to assure maximum ultimate utility.

Equally obvious is the fact that our Defense Department is a huge and complex organization. We remember and it is to be hoped the picture is burned forever deeply into our memories, the utterly stupid competition which prevailed between the Army and the Navy during the last war in the procurement of materials which were in short supply. Wide variations in packaging requirements between the Army and the Navy and even between technical services of the Army and between bureaus of the Navy were the rule rather than the exception. The resultant confusion became such a dominant factor in delaying the movement of badly needed war material that corrective action was taken late in 1944 with the formation of the Navy Packaging Board, followed immediately with the establishment of the Army Packaging Board, and a few weeks later by the formation of a Joint Army-Navy Packaging Board. This latter board has since been replaced by a Packaging Agency of the Munitions Board whose principal function is the standardization and coordination of Army, Navy, and Air Force packaging effort. The Air Force has its packaging board now, and each of these three service packaging boards serves as a coordinating committee on packaging for the entire service it represents.

Let us at this point agree on one very important fact: this country has fought its last war in an economy of plenty; from here on we fight in one of scarcity. No longer is this great nation of ours one of inexhaustible resources. On V-J Day in 1945 half of the total timber harvest of the United States was going into containers and packaging materials. The excess production capacity of unbleached kraft paper in the United States is only 7% above the 1950 production of 2,300,000 tons! Corrugated and solid fiber container board production in 1950 was within 4% of the nation's total capacity to produce! Last year we produced waxed papers, cellophane, tinplate, aluminum, aluminum foils, steel, acetate, and polyethylene at our full rated capacity and there wasn't enough to go around! And remember, in 1950 military requirements accounted for less than 10% of the nation's total consumption of packaging materials.

Planning within the Defense Department for packaging of military stores presents a very real and complex problem. Actually we must plan for many eventualities; actions ranging

all the way from the present activity in Korea to all-out global war.

The people who are administering the packaging program in the military services are extremely conservation conscious. We hear a lot these days about conserving paper and paperboard, but not nearly enough is being said about conserving trees! We are determined that more containers must be produced from each tree. This means that more and more coarse papers are needed to make the kraft-veneer laminated panelboard we will require for wood-cleated boxes, to meet our needs for improved ration boxes, to provide the fiberboard boxes for clothing to save weight, cube, and trees. The paper industry is planning soundly to provide the additional tonnage we shall require, "but only God can make a tree"! New processes must be provided to make other fibers available for coarse paper production.

More reinforcing materials are going to be needed for strengthening and thereby broadening the use of pressure-sensitive tapes and paper laminations in order to make our military packages impervious to attacks of moisture, mildew, and rot.

More paper and paperboard must be made available to enable the military services to make maximum use of the new volatile corrosion inhibitors.

The new and wider ranges of temperature which must be considered in our current planning place an even heavier burden performance-wise upon the packaging materials we are using. Cement sacks which formerly were of multiwall construction employing asphalt-laminated kraft paper must continue to be made from coarse paper but asphalt cannot be used because it will not stand the low temperature requirements we are compelled to meet.

Intimate wraps of greaseproof papers will no longer hold the synthetic types of greases and preservatives which field conditions require us to use. New materials must be provided which will accomplish this.

We used millions of asphalt laminated waterproof case liners in World War II to protect the contents of boxes from damage caused by liquid water. Common sense dictates that more of these water barriers should be included as an integral part of the containers themselves.

As a matter of fact, most of the packaging materials used by the military services were developed during the last war and these were designed from a performance standpoint to meet a combination of high temperature and high humidity conditions. Now, in addition to these we must engineer our packaging materials to meet low temperature requirements. Some of the problems encountered here present a real challenge to paper manufacturers and converters. Particularly are the converters on the spot for we are largely dependent upon combinations of paper or those involving the use of paper with other components, and of course nearly always in fabricated form.

But just as the paper industry came through for us early in the last war when we needed a truly weatherproof fiberbox material by developing V-board and in a matter of only days, I feel confident that you people in this industry can again take our problems and come up with sound and practical solutions.

Now just a word as to what you can expect from us. In the Navy, no demands will be placed upon industry which involve radical departures from normal industrial procedure in that particular field, unless it can be established that the security of the country is in jeopardy. This is certainly not to be construed to mean that we intend to permit the material losses due to inadequate preservation and packaging we experienced in the early months of the last war. We learned a great deal about the preservation and packaging of war materials and we intend to put that know-how to practical use. But everything we ask industry to do in this connection will be based on first-hand knowledge of the facts; the policies which are so necessary in a program of this magnitude are being written by skilled technicians who know their business, in coordination with their counterparts in industry.

E. C. Jahn, College of Forestry, State University of New York, L. F. Engelhart, Interchemical Corp.; H. Spector, St. Regis Paper Co.; and H. A. Spencer, Knowlton Bros.

We are determined that our pleasant relationship with industry shall be maintained and we intend to keep it friendly.

A Few Thoughts on Stream Pollution

Horace A. Spencer

To PARAPHRASE an oldie, "Much has been said about stream pollution in the pulp and paper industry but little has been done about it."

Since the beginning of time there no doubt has been stream pollution of one sort or another. As civilization has progressed there has been an increase of pollution and an increase of hazards to the health of the communities and to industry.

By concentrating the population in the villages, towns, and cities, and by the development of industries, large and small, pollution of the water became a major factor not only to the conservation and health departments but to industry as well. After all, there is the problem of processing water. For too many years in the past the thought, if there were any thoughts about the problem at all, was that the streams and rivers were a natural means for the removal of the offal whether it came from the municipalities or industry. Like so many ugly situations in life, nothing or very little is done about it until pressure is put on the lawmakers to do something about the situation. So it was with the water pollution.

This pressure became so great that the Federal Government passed a law on pollution abatement and placed it in the hands of the Surgeon General to administer. Apparently, the Federal Government was concerned about the health problem. New York State passed a law on pollution abatement that ties in with the abatement laws of the bordering states and the states affected by the water that flows from New York State. There are many other states that have passed laws on water pollution abatement.

Here in New York State a great deal of pressure was brought on the legislature by the conservationist, fish and game clubs, and health organizations. These people are apparently sincere in their purposes and seem to have plenty

HORACE A. SPENCER, Research and Technical Director, Knowlton Brothers, Watertown, N. Y.

of money to use for lobbying. Most of them, if not all, are nonprofit organizations. It seems too bad that industry did not get the jump on them by demanding better processing

Present officers of the Empire State Section: Foster P. Doane, Jr., Sandy Hill Iron & Brass Works, Chairman-elect; R. N. Prince, American Cyanamid Co., Secretary-Treasurer; and J. S. Reichert, E. I. du Pont de Nemours & Co., Inc., Chairman

water. Now that the law is passed it would behoove industry, and especially the pulp and paper industry, to keep on its toes to insure a reasonable interpretation of the law.

At various meetings of the special committee on Pollution Abatement, a subcommittee of the Joint Legislative Committee on Interstate Cooperation, it was my observation that the conservationists, fish and game clubs, and health organizations, were very, very forceful in their arguments that the streams, rivers, and lakes be cleaned up. They want the waters of this State pure enough for fishing and swimming, and purer water for domestic uses.

There is no doubt that if the chemist had not devised methods to insure the purification of the waters for drinking purposes, a more severe law would have been passed long ago. I observed, as a member of the subcommittee, that regardless of the pressure applied by various groups the committee and the lawmakers were intent on a reasonable law. This fact was so stated as the intent when the first draft of the law was presented to the Assembly and the Senate.

It should be pointed out here that, in reality, it was not entirely necessary to pass a special law for water pollution abatement for the Health Department of New York State had and has enough power to stop anyone or any group from contaminating the waters to the extent that they would be injurious to the public health. This power, however, was seldom used. Maybe because one department did not want to assume a responsibility so great as this. By the passing of the law on pollution abatement the following New York State departments are represented: Department of Health, Department of Agriculture and Markets, Department of Commerce, Department of Conservation, and the Department of Public Works. This was done so that the responsibility would be divided and that everyone interested would be represented so that it would be a reasonable law and have a reasonable enforcement. Reasonable so that the enforcement of the law would not be an unbearable burden on municipalities and industry. Should only one department be responsible for the enforcement of the law, or had only one department drawn up the law there would be the possibility of yielding to pressure. Such was not the case, however, for advice was taken from all departments, as well as outside interested organization and industry.

It would not be reasonable to assume that the enforcement of the law would apply to industry alone and let the municipalities continue to pollute the stream with raw sewage. It is well known that a person, watching the effluent from a mill making a deep red paper, will say, "Look at the contamination coming from that mill. It will kill all the fish in the river." It can be, that just above or just below the red-white water, a sewer dumping raw sewage is located. This person will say nothing about it because, as a rule, he does not see it. Yet the fact remains that the same person could drink the water containing red dye with little ill effect, but death would be at his elbow should he drink the raw sewage. Such is human nature. There are well over a hundred municipalities and over 400 smaller communities that need sewers and treatment works. It is estimated very conservatively that it will take some $400,000,000 for these purposes. We have here a problem of finance. There are very few villages, towns or cities that have the funds available or can raise the money and stay within their bonded indebtedness limits. This, however, will not be an obstacle of the first order for it is possible to have amendments to the State Constitution to float bonds to be paid for by sewer rental. These rentals would be a must for the home owner. Thus the municipalities can and will clean up when they are told to do so.

Now let us consider industry, particularly the pulp and paper industry. Should the present national conditions prevail I doubt very much if a great deal of pressure will be put upon industry to clean up too much. This, of course, applies to the municipalities as well. There are at present, as you all know, shortages in the critical materials needed for such improvements. If a third world war should start, it is in the realm of possibilities that this civilization would not need a stream pollution abatement program. We must proceed, however, with the thought that the program will be put in force, and the pulp and paper industry will have to do something about their waste problem.

As you all know, each mill has its own problem in the cleanup program. In order to be in the competitive markets a great number of mills have had to put in various devices to save them materials thereby cleaning up the effluent from their mills so that with an increase in production the amount of contamination going into the stream and rivers has not increased and in some cases has been reduced.

To aid the mills in their cleanup program there is an organization that can and will give them assistance. This organization is known as the National Council for Stream Improvement, Inc., 271 Madison Avenue, New York 16, N. Y. Russell L. Winget is the Executive Secretary. This organization has research projects for the pulp and paper industry in the following outstanding institutions: Mellon Institute, Rutgers University, Bates College, Virginia Polytechnic Institute, Louisiana State University, University of Michigan, Institute of Paper Chemistry, Oregon State College, Purdue University, and Western Michigan College. The information I have at this time gives reports from the following:

Rutgers University—Work on white water: rope, rag, and jute pulping waste
Louisiana State University—Alkaline pulping
Oregon State College—Sulphite waste liquor

I have not seen these completed reports so cannot comment on them. There is little doubt that they would be of interest to the mills concerned with the different types of pulping.

It might be of interest to you to know of the work that has been accomplished by the Eastern Lake Ontario District of the National Council for Stream Improvement. Under the able leadership of J. H. Heuer, as chairman of this district, help was obtained from Harry W. Gehm, Technical Adviser

to the National Council, and Frank R. Burde, New York State Resident Engineer for the National Council, to run a survey on the Black River watershed. The mills on the river contributed man power and the transportation, and the St. Regis Paper Co. gave the use of their laboratory at Deferiet, N. Y. If nothing else was accomplished, it proved again that neighboring mills could and would get together to work for a common cause. Still more than that came from this work.

It was believed that this survey should be made so that the mills concerned would know to what extent the streams were being polluted and about what to expect as a classification for the river from the New York State Water Pollution Control Board. It was also believed that when the results of this survey were compared with previous surveys some conclusion could be drawn as to the increase in pollution due to the increase in production and population. The results of this survey and the conclusions reached in the comparison with the previous survey must be kept confidential for obvious reasons.

A great deal of credit must go to Mr. Gehm and Mr. Burde for the efficient way that they cooperated with Mr. Heuer and his staff. It might be well for Empire State Section of TAPPI to set up a permanent committee to act as a guide and a clearing house for information that is available and that will become available as to methods and equipment to clean up the pulp and paper industry's white water. Armed with this information and whatever information can be gathered concerning the progress that the cities, towns, and villages are making with their sewerage treatment program, the mills would be forewarned.

I believe that a committee such as this could be of real benefit, not only to TAPPI, but to the pulp and paper industry of New York State. After all, this is the industry that pays us, and our best service to it is more than justified. A committee such as this, if it functions properly, could get information from the State as to the plans to the various municipalities on the various watersheds pertinent to the pulp and paper industry. This committee would inform the industry when the muncipalities would be able to put an abatement program into effect, thereby giving the industry a yardstick as to when they would have to clean up their effluent. This committee could get the procedure for new methods from various concerns that are interested in the abatement problem and wish a distribution of information to the people interested. I believe that such a committee would be a worth-while project for the Empire State Section. I do not mean that this committee could supplant such organizations as the National Council for Stream Improvement, Inc., but I mean that such a committee would prove its worth in knitting the industry together in a common cause and would be a means of disseminating knowledge of the problem throughout the industry. This committee could develop into somewhat of a force to insure that the law has a reasonable interpretation insofar as the pulp and paper industry is concerned.

The forming and the power of this committee, of course, rest entirely with the Executive Committee of the Empire State Section. The success or failure of such a committee would rest entirely on the powers delegated to such a committee.

Out of every forced improvement comes some gain of one sort or another. In the cleanup of the pulp and paper industry, and I say cleanup not in the sense that they are the largest contributors of pollution or that they have thrown materials away with abandon, there will come a saving, not only in chemicals, but in new products derived from the waste materials. No doubt many of you are aware of the work that has been done alone these lines. By-products such as lignin plastics, alcohol, vanillin, and many other products, are now being produced and many, many more will come into being.

It would be a mistake to assume that small mills could put in reclamation systems and show a profit on these systems in new products for the very simple reason that the volume is not

District chairmen of the Empire State Section of the Technical Association of the Pulp and Paper Industry: Front, l. to r.: H. Spector, St. Regis Paper Co., Northern; H. D. Cook, Sweet Bros. Paper Mfg. Co., Central; W. R. Willets, Titanium Pigment Corp., New York. Rear: R. D. Moynihan, Finch, Pruyn & Co., Eastern; and I. V. Earle, Upson Co., Western

there. They could not compete with the larger mills in this field. I do not advocate the small mill going out of business, nor do I believe that the State wants the small mill to shut down, but I do believe that there are many things that small mills can do to help themselves clean up without going bankrupt buying new machinery.

The intermediate size mill will no doubt have the worst problem of all the mills due to its necessarily large volume of effluent, and yet the volume is not large enough to go into by-products. The large mills can do a lot toward easing their cost of the cleanup with by-products.

At the present time many companies allied to the pulp and paper industry are working on equipment, chemicals, and methods to aid in this cleanup. From some of the work that I have seen, most of this equipment is quite elaborate and quite costly. No doubt any equipment that is necessary will come at a high price.

CONCLUSIONS

1. There is a law in New York State for the abatement of water pollution and it is a reasonable law.
2. It is up to the pulp and paper industry to see that the interpretation of the law is as reasonable as the intent of the law.
3. The mills of the various watersheds should band together, proceeding along the lines followed by the mills in the Black River watershed, to run a survey so that the mills will have some idea as to what classification their water might receive from the State Classification Board.
4. It is known that all the waters will be classified but it would be a big mistake to spend vast sums of money before the classification has been made and approved.
5. The knowledge of an approximate classification in advance of the permanent classification would help the mills make some of the necessary changes in a manner that might not be as costly as waiting until the board classification is made.
6. The Empire State Section of TAPPI should set up a committee on pollution abatement to disseminate knowledge to the pulp and paper industry.

Printing Ink and Equipment Development and Their Effect on Paper Requirements

L. F. Engelhart

THE graphic arts has built up an almost 7 billion dollar industry on the foundation that paper and paperboard will print. More than half of these pulp-derived products, or some 15 million tons annually are printed in some fashion or other.

As in your papermaking industry, the trend in printing has been, and undoubtedly will continue to be, "more speed" and its present-seeming synonym "more production." Again, like your fourdriniers, the speed of the graphic arts' presses, both large and small, has been stepped up in feet per minute—or in printers' terms "impressions per hour"—to outputs considered impossible to achieve just a short time past.

Obviously, such demands for speed and more speed have, for their attainment, necessitated significant ink, press, and printing equipment developments which, in turn, have had their effect on the paper requirements needed to meet this high-geared modern tempo. It is the purpose of this address to discuss those requirements that seemingly need be most stressed to satisfactorily suit these new developments.

GOOD PRINTABILITY IS ALWAYS A NECESSARY REQUIREMENT

Now, it is to be remembered that it is not just a matter that paper and paperboard be printed at these high rates—but *how* they print at these great production speeds. Publications, packaging, and containers account for most of the printing on the aforementioned huge volume of such paper and board; and the *quality* demands, as well as the production requirements of the printing on these products in the form of text, illustration, and decoration, have been on a decided increase.

Hence, the printability characteristics needed to satisfy such quality demands, certainly are among the more important of the paper and board requirements for printing at *any* speed or production schedule. Therefore, since "printability" still seems to be a rather controversial subject, I think I had better momentarily digress to discuss printability, in general, before touching on the specific requirements (which mostly involve printability) needed to suit new developments.

Unfortunately, it is most difficult to adequately define and presently almost impossible to scientifically specify printability. Larocque (*1*), Eckhart and Burnett (*2*), Diehm (*3*), and others recently have made good progress in putting printability on a specification or numerical basis and it is hoped their efforts will be continued to cover all types of stocks and printing processes.

In the interim, we ordinarily have to express printability in relative rather than absolute terms. The reason for this is that printability is usually a variable that is a function of, and dependent on, other variables as: ink, stock, printing process, press speed, amount of impression, drying means, plate, job, atmospheric conditions—and sometimes, the condition of the pressman himself. Furthermore, what might be considered good printability in one class of work, as on cartons, most likely would be considered to be quite the contrary in comparison with some other class, as on magazines.

However, I think we can somewhat simplify this aspect as to what constitutes good or satisfactory printability, or its requirements, if we consider it from the relative aspects as follows:

WHAT IS SATISFACTORY PRINTABILITY?

Printing is a reproduction process. Its aim is to give multiple reproductions of whatever is furnished as the original. This original or so-called "copy" may consist of art work, photographs, text, and type matter, and any combinations thereof. Now it is the printer's job to reproduce such originals, or copy, in close facsimile, uniformly, efficiently—and usually in large numbers.

To do this, he ordinarily uses any one of the three major printing processes (as letterpress, offset, or gravure)—which differ from each other essentially only in the design or structure of their ink transfer medium, or plates. The multiple transfer of the ink from these various plates is the fundamental process of all these printing methods. The efficiency and exactitude in which these respective plate designs or images are transferred (in register) onto the paper or board, and the visual similarity of such transfer to the originals, constitute what I consider the primary printing characteristics of the paper and ink variables involved.

Now the most important paper and board properties or characteristics that govern or control such printability seem to me, to be:

THE PAPER PROPERTIES THAT GOVERN PRINTABILITY

(1) Surface smoothness and resilience, (2) ink receptivity and affinity, (3) surface strength or pick resistance, (4) color and reflectance, (5) opacity, (6) dimensional stability, (7) body strength, (8) chemical reactivity, (9) abrasiveness, (10) grain or fiber orientation, (11) moisture content, and (12) uniformity.

Several papers could be, and probably have been, presented on how the foregoing paper or board properties should be varied to arrive at the happiest paper-ink relationship according to the given printing process and the variables thereof.

Since more speed is the trend, it is, of course, the first requisite that the stock have the physical and mechanical perfection and qualities that permit it to be handled through the given process at such desired speed. Furthermore, since high speed accentuates all paper problems, this should be taken into consideration in the extrapolation of any empirical specifications of the foregoing properties into terms of good printability. In such translation, the first three of the listed properties (in addition to impression) essentially dominate the actual mechanics of the ink transfer from the plate to stock which operation is the crux of all printing. Such transfer properties to a large extent govern the more important ink-paper printability characteristics as: coverage, lay, finish, pick, set-off, trapping, strike-through, stick, smear, and even drying rate. However, remember that the final printability, as judged by facsimile reproduction in mass production, is a composite or total result of *all* these listed characteristics, and perhaps a few more.

PRINTING INK STRUCTURE AND METHODS BY WHICH INK MAY DRY

Since most new paper requirements center upon the enhanced speed of ink drying, I will give some coverage on general ink structure in relation to drying, before I touch on specific cases. This follows:

All the most important present-day printing inks consist of pigments (or color component) finely dispersed in a vehicle or "carrier." Whether the printing process be letterpress, offset, or gravure, it is the first requisite of this vehicle to carry the pigment successfully up to and through the application or transfer process. As a second requisite, this vehicle usually also has to bind or hold, and many times protect, this color component after such deposition onto the paper or stock.

Now for obvious physical and mechanical reasons, the lightninglike deposition or transfer applications (sometimes $^1/_{500}$ second) needed to meet the higher speed requirements in all processes, necessitate the ink system be highly mobile or even fluid up to and through the instant of impressional contact. At the same time, this great speed necessitates that this same erstwhile fluid ink become essentially solid almost instantly after said impression.

L. F. ENGELHART, Head of Eastern Products Development Laboratory, International Printing Ink, New York, N. Y.

This right-moment instant transition of the ink system from the liquid to the solid phase has been, and will continue to be, the trend and goal of present and future printing ink and press-auxiliary developments. Anything that you papermakers in your formulations can contribute to that end, will greatly lessen the burden of either or both the foregoing in this essential requirement for highest speed printing.

This liquid-solid transition, or drying of inks, is governed largely or entirely, by the vehicle. The present methods by which this vehicle, its components, or the ink system, may dry are usually found in one or combinations of the following: (1) absorption, (2) evaporation or volatilization, (3) oxidation, (4) polymerization, (5) precipitation, (6) gelation, (7) cooling or chilling, and (8) fusion.

Most of these eight basic drying methods are physico-chemical phenomena. So far, all of these methods have not shown equal merit for the promotion of fastest drying. They likewise differ in their adoption to different drying equipment aids.

From a mechanical equipment viewpoint, the present most significant and practical acceleration of ink drying has been through the use of auxiliary press apparatus that will apply heat or moisture, in one form or another, onto the freshly printed ink film.

These two press-application aids have become so commercially prevalent as to have the two ink classes used, named after the respective drying operation. These are: (1) heat-set inks, and (2) moisture-set inks. These together with their particular paper requirements are separately discussed below:

HEAT-SET INKS AND THEIR SPECIFIC REQUIREMENTS OF PAPER

Here, in addition to the normal requisites for good printability in my afore-listed twelve "printability characteristics," the paper requirements are that it satisfactorily withstand the heat-drying operation without scorching, blistering, embrittlement, and other either temporary or permanent, disfiguration or loss of strength.

As practically all of the highest speed heat-set printing is web-fed, it is obvious that even temporary loss of strength makes the stock vulnerable to time-consuming and costly web-breaks. Hence, even though the applied tension, as through spring rollers, is ordinarily only a few pounds per inch web-width, there are instances of certain amount of jerk or uneven tension that may apply local tensile strains sufficient to break or tear such heat-weakened webs.

Now by scorchproof under the conditions of printing, I do not mean that the stock has to be asbestos coated or fireproofed. Originally back in 1935–36, we suspected this might possibly have to be the case, as in first heat-set installations a fire-extinguisher seemed as necessary an adjunct to printing as a solvent flit-gun; and a fire underwriter seemed to be a regular member of the press crew. But I do mean, that in present highest speed heat-set printing there are many cases in multicolor heavy film jobs where a web temperature of over 400°F. for a few seconds may be reached. Usually, however, the pressman tries to dry at around 300°F. web temperatures, or less.

In the highest speed printing, as 1000 f.p.m. and faster, the ink maker has frequently been accused of so formulating his product as to make it necessary to "fry" both ink and paper. The impressive array of heating auxiliaries as steam drums at 325°F., air-jets at 600°F., live steam at 700 to 1000°F., and gas or electric refractories at several thousand degrees seem satanically designed for that purpose. However, to compensate for such high temperatures, the exposure times have been shortened and, after such short-time heating, essentially instant cooling has been effected by chilled roller web-wraps. In cases of slowdown or stop, ingenious devices of air-blast cooling and retractable web leads have minimized scorch and fire hazards.

Syracuse pulp and paper alumni get-together breakfast at the Empire State Annual Meeting

Even so, heat-set spoilage of stock still keeps wastage on high levels in such printing, and heat-resistivity is a requirement to consider in designing stock for such high-speed publication, bag, and package wrap work. Generally, a 5 to 6% moisture content seems the most "happy mean" for such printing.

Another important requirement of the paper used in heat-set printing is that the stock have sufficient surface strength to resist "picking," or removal of coating or fiber, during the printing operation and make-ready periods. It is a simple physical law that the "pull" of an ink (or its relative tack) is increased directly with the speed at which the paper leaves the ink plate. Therefore, the very fact that heat-set printing permits the manyfold higher printing speeds than without such forced drying, means that the pick-resistant requirements must be of a similar higher order.

Furthermore, heat-setting permits the simultaneous drying of several ink films, as in the so-called "wet" multicolor printing, wherein as many as four colors have to be more or less superimposed, and therefore tack graded, to efficiently accomplish such superimposition. This means that the first-down ink must maintain sufficient "pull" to lift the less tacky second-down color from the plate—and the second, lift the third, and so on, down to the successful trapping of all four colors.

Now for quality letterpress or offset printing, the last-down colors cannot be so low in tack or "soupy" so as to give sloppy or mottled transfer on underneath ink or bare stock. Consequently, this means the first-down color usually has to be appreciably tacky (sometimes of the order of 25 on the 400 r.p.m. Inkometer—or 8, or higher, wax test) to "foundation" the succeeding colors. It is therefore obvious that the pull of such relatively tacky ink at a thousand feet per minute or more speeds, requires appreciable pick-resistivity in such printing.

Another factor that frequently necessitates a relatively high order of pick resistance in connection with heat-set inks, is their tendency to "tack up" on the rollers during shutdown, make-ready, press-inching, and even during some steady operational periods. This is due to the fact, most of these inks obtain their essentially instant drying by heat vaporization or volatilization of solvents from their vehicular components. Despite "juggling" of vapor pressures and co-solvency, these fast heat-dry solvents or systems often give sufficient evaporation, on the 90 to 130°F. distributing and form rollers, to markedly increase the ink tack over the original or in-the-fountain state.

In some unpublished work, the author has found that on

rotating rollers, the tack of many such inks increases logarithmically over uniform periods of time. This indicates that such tack increment may take distinct and appreciable jumps during the ink transit from fountain to plate—particularly, in cases of light ink flow and small subject forms.

One of the newer developments in this field are heat-set offset inks capable of being printed and dried at speeds almost comparable to the present fastest letterpress web printing. Now in such lithographic work, all the foregoing pick-resistant requirements must be met, and overcome—but, in addition, when the paper surface is moistened with a thin film of water or 4.0 pH fountain solution. In such printing, there is overall contact of the paper surface by a moist rubber blanket. This moisture, which it originally acquires from the wet plate, first hits the surface of the fresh sheet or web at the instant of the first color impression—hence, in this case, and in only single-color impression or printing, probably hasn't much time to accomplish much weakening or softening of the surface.

However, in multicolor printing (which is the trend)—subsequent ink and moisture films, again, and again, up to three additional times, hit the same sheet's surface. Here, by the time these later impressions take place, moisture and fountain acid have had a good chance to soften and weaken fiber or coated surface. Add to this, the fact that litho inks must usually be inherently more tacky than other inks—and you can readily realize why I stress the surface bonding and pick-resistivity requirements for such class of heat-set printing.

MOISTURE-SET INKS AND THEIR SPECIAL REQUIREMENTS OF PAPER

Many of the headaches of the heat-set requirements of paper and board are minimized or absent in moisture-set printing for reason the latter usually tends to add to, rather than take from, the moisture in the stock being printed.

Moisture-set inks, as their name implies, are so designed that moisture in one form or other will set or dry the ink quickly. This drying mechanism is essentially precipitation which, if you remember, is one of the eight basic drying methods I listed in the forepart of my address.

Typical of such inks is a system wherein the vehicle consists of a water-insoluble binder dissolved in a water-miscible hygroscopic solvent. This vehicle upon contact with water or its vapor absorbs same sufficiently to water-dilute the solvent and quickly precipitate the binder—which then, essentially in the "dry" state, holds the pigment onto the stock. The residual, diluted, and now useless solvent, is simultaneously removed by natural stock absorption and evaporation, or forced volatilization.

Many types of such inks necessitate the trickiest type of formulation and "know-how," involving delicate hygroscopic control and balancing of the system, so as to maintain adequate stability on the press rollers under all common humidity variances and at the same time preserve speed and sensitivity to steam or moisture "set" on the paper. I have taken some length to give you the mechanism of these inks, so you may appreciate somewhat the "ordeal by water" the paper or board may have to undergo when used with these inks.

In their present status, moisture-set inks are widely used in the printing of cartons, containers, wraps, and other packaging. Since they can be formulated to give no initial or after odor as well as fast drying, they have almost completely replaced oil inks, and most heat-set inks, on food wraps and containers.

A fair amount of carton stock and corrugated board is printed with these inks wherein the prints are simply air or "pile-dried" as with the older oil inks. Actually, much or most of this room-temperature drying takes place due to a "set" caused by the natural or inherent moisture content of the board. While such usage has not materially added to the speed of operation of these sheet-fed presses, it nevertheless has greatly helped in lowering costs and increasing over-all production for reason of quick and "positive" drying on the just-made "green" or moist board—thereby shortening operation cycles and eliminating storage space and preconditioning.

Such air-dry usage of these inks seems to impose no particularly new or stringent requirements of the stock—except that it will naturally be more pick susceptible due to the allowed high moisture content—frequently, from 7 to 10%.

In the lighter weight board and paper field, wet or dry steam is ordinarily used, which accounts for the nomenclature "steam-set inks." Since drying time by either low pressure or high pressure steam with such inks is usually a matter of seconds, or less, such usage has become increasingly prevalent. Much of such printing in connection with foodstuffs is wax coated (as bread-wrappers, etc.) and the quick drying without odor, and ability of these inks to withstand practically any of such wax processing makes them ideally suited to such speedy and frequently tandem or streamlined operations.

Since the steam application comes after printing, the stock requirements, as far as the ink is concerned, are merely that it withstand the tack of the ink at the speed of printing, and that the glycol and hydroscopic solvents in the ink do not unduly soften the surface by action on coating binder or sizing. However, the subsequent "live" steam application necessitates certain noncrackling, noncurling, and dimensional stability requirements—and sometimes, wet-strength and water-resistant characteristics suited to the particular operation.

To eliminate the hazards of actual water contact of the stock, as through condensation, drip, etc., and to increase speed and minimize press installation space, there is a present and seeming future trend to use higher steam pressures and more superheating. This trend has reached a point where there are now some experimental and semiproduction installations making use of 700 to 1000°F. steam. Live steam of this temperature impinging upon a paper surface may necessitate some of the requirements now demanded in many of the more conventional heat-set printings. Even so, you papermakers have already hurdled this requirement, and there seems no present reason to doubt we may have another significant aid for our ever-increasing tempo of high-speed printing.

REQUIREMENTS FOR OTHER QUICK-SET INKS

Up to now, I have only stressed developments and requirements in heat-set and moisture-set printing because it is in these fields that sales increment in tonnage of pulp products, and poundage of ink, seems to have made most significant strides.

However, at the same time, the smaller printers have demanded speed-up and aid in their own competitive work and fields. Though these printers individually do not consume or produce in astronomical figures, they collectively constitute many of the bread-and-butter accounts for many of us. As a consequence, a class of press-stable inks has been developed which in their sheet-fed printing will set in a few seconds, and dry in a few minutes, without the use of heat or other forced drying. The merits of such inks to the small printers are that they can backup, or print the reverse side, almost immediately, and, if necessary, use semistreamlined "work and turn" and tandem operation without the use of costly heaters or, at best, with simple infrared lamp drying acceleration.

Such inks are usually designed to dry by selective absorption or "filtration" of certain components of the vehicle. In such instance, almost immediately upon impressional contact, the lower viscosity or solvent component of the vehicle is "squashed" and absorbed into the stock, and the binder "preferentially" left on the surface to bind the pigment into an essentially instant-dry film. This physical or paper-ink reaction, for best effectiveness in set-speed and initial and ultimate rub-resistance, seems specific in its requirements

of the stock's surface pore size, and the amount and character of the body stock voids.

Conventional coated papers seem to satisfactorily meet most of these ink and printing requirements, but special coating, coating binder, body stock, and sizing, seem to give even distinctly better results. Such paper-ink physical reaction together with trigger-speed chemical catalysis, and other ink chemists' artifices to get our aforementioned goal, the instant transition of the ink system from the liquid to the solid phase, seem likely future means of literally taking some of the "heat" or "steam off" in our present and future fastest printing.

In conclusion, I feel sure that the present trend of more speed and production in today's developments of printing ink, paper, and equipment, will continue into the future. Furthermore, I feel I need not be clairvoyant to predict that the maintenance of the present, or even better, high standards of printability and reproduction, will be among the important requirements needed to make any such new developments lastingly successful.

LITERATURE CITED

1. Larocque, C., Axelrod, B., and Clark, S., Measuring the printing quality of newsprint. Paper presented at Tech. Sec. Canadian Pulp & Paper Assn., Montreal, Jan. 24–26, 1945.
2. Eckhart, C., and Burnett, L. K., Numerical evaluation of printability of paperboard. Paper presented at 36th annual meeting, TAPPI, New York, Feb. 19–22, 1951.
3. Diehm, R. A., The elimination of the human element in the determination of printing quality. *Tappi* 33, no. 2: 42A–48A (1950).

RECENT BOOKS

Sources of Information in the Graphic Arts. By George J. Mills, Asst. Professor, Department of Printing, Carnegie Institute of Technology, Pittsburgh, Pa. Carnegie Press, 1951. Paper, spiral-bound, 6 × 9, 70 pages. $2.00.

A compilation, to be reissued at intervals, giving the principal sources of information on subjects relating to the graphic arts. The book is divided into two main parts: I. Bibliographic Section and II. Sources.

The Bibliographic Section covers bibliographies; books on such subjects as bookbinding, color, copy preparation, cost estimates, fine printing, lithography, paper, photoengraving, and processes; periodicals dealing with packaging, paper, printing processes, and publishing; and directories. The Sources Section deals with libraries, schools, trade associations, labor organizations, and research programs.

Although the book contains several errors insofar as it deals with subjects on paper, the reviewer has acquainted the author with these so that subsequent revisions can be more accurate. The errors do not materially decrease the value of the book, and it is quite likely that many will find it to be of considerable labor-saving service in enabling them to locate sources of information on short notice. Since the author is a specialist in the printing field his references are undoubtedly, exceptionally good in this scope. It is evident that the book represents a built-up desire by the author to prepare an index for his own use. In sharing it in its present form he has performed a very useful service.

Chemical Engineering Costs. By O. T. Zimmerman, University of New Hampshire and Irvin Lavine. Industrial Research Service, Dover, N. H., 1950. Cloth, 6 × 9, 419 pages. Illustrated. $7.00 in U.S.A., $8.00 elsewhere.

A large number of collaborators have joined with the principal authors in preparing chapters dealing with their respective specialties. Among the subjects covered are heat exchangers, evaporators, driers, filter presses, centrifuges, size reduction equipment, dust collectors, fans, centrifugal pumps, steam jet ejectors, rotameters, water conditioning, steam generation, and industrial materials.

In addition to this book the Industrial Research Service announces a quarterly publication "Chemical Engineering Costs Supplement" being offered at $5.00 per year. These quarterlies will contain the latest material and labor indexes.

Since cost estimates are a necessary part of every chemical engineering design in the pulp and paper industry, the present volume offers basic benchmarks for many unit operations. Although costs do not remain constant the fundamentals outlined can be brought up to date by applying the factors derived from the current material and labor indexes.

Small Plant Management. Edited by Edward H. Hempel, Chairman, Small Plant Committee, A.S.M.E., New York. McGraw-Hill Book Co., Inc., New York, 1950. Cloth, 6 × 9, 549 pages. Illustrated. $6.00.

This book was prepared under the auspices of Management Division of the American Society of Mechanical Engineers and deals with plants or technical services employing 250 men or less. There are 300,000 of these in the United States. The work is based on a wide investigation of the management of such plants. As in many books of its type, each of its many chapters is written by a different author.

Among the subjects covered are small plant financing and banking, top management planning for the small plant, its organization, operation and control, labor relations and how to get along with unions, how to obtain best productivity, how to do technical research, how to get best sales, how to do and use accounting. A bibliography and suggestions for a small plant library is appended.

White Mineral Oil and Petrolatum. By Erich Meyer, L. Sonneborn Sons, Inc. Chemical Publishing Co., Inc., Brooklyn, N. Y., 1950. Cloth, $5^1/_2$ × $8^1/_2$, 135 pages. $4.75.

Although a large proportion of the contents of this book deals with medical and pharmaceutical subjects it is of interest to many in the paper industry who have occasion to use the microcrystalline waxes. During the recent and present wartime periods the use of this material in packaging papers is well known. The principal subjects treated are technical aspects, applications, methods of testing, and shipping and handling of mineral oil and petrolatum.

Laboratory Design. Edited by H. S. Coleman, Asst. Director, Mellon Institute for Industrial Research. Reinhold Book Division, New York, 1951. Cloth, 9 × 12, 404 pages. Illustrated. $12.

This book is a major reference source of constructional information on laboratories prepared by the Committee on Design, Construction and Equipment of Laboratories of the National Research Council.

Part I deals with interior construction materials, furniture, plumbing, lighting, power, ventilation, and safety precautions. Part II relates to various teaching laboratories. Part III covers industrial laboratories of various types, and Part IV consists of concise descriptions of some modern laboratories such as Battelle, Mellon, Johns-Manville, Esso, Bell Telephone as well as several university and government laboratories.

It is a remarkable handbook on the subject, prepared by men who use laboratories and know exactly what they want in such an institution. Two TAPPI Committee Chairmen, Harry F. Lewis of the Institute of Paper Chemistry and

E. M. Jenkins of the Johns-Manville Research Center, are included among the authors.

A Manual of Plastics and Resins. Edited by William Schack. Chemical Publishing Co., Brooklyn, N. Y., 1950. Cloth, 6 × 9, 547 pages. Illustrated. $10.

This book, prepared in encyclopedia form by the editor and members of the Society of Plastics Engineers is a comprehensive survey of the materials, processes, products, and equipment of the plastic industry. About 1500 subjects are covered, arranged in alphabetical order. About 170 contributors supplied information. The appendix gives trade names, composition, and manufacturers. Nearly every subject that might occur to an individual interested in plastics or resins is covered. The initials of each authority are placed at the end of every item.

Colorimetric Determination of Traces of Metals. 2nd Ed. By E. B. Sandell, Professor of Analytical Chemistry, University of Minnesota. Interscience Publishers, Inc., New York, 1950. Cloth, 6 × 9, 673 pages. Illustrated. $9.00.

This is a second edition, revised and enlarged, of the Chemical Analysis Series. The first edition was issued in 1944. Although very few new colorimetric reagents of importance have been introduced since the first edition there has been a flood of papers and further applications of previously known reagents. The pattern of the first edition has been followed. This covers colorimetric trace analysis and procedures for determining races of most metals.

Chipped Wood Production and Uses. Northeast Wood Utilization Council, P. O. Box 1577, New Haven 6, Conn. Paper-bound, 6 × 9, 135 pages. $2.00.

A compilation of the papers presented at the Sept. 15, 1950, meeting of the Northeast Wood Utilization Council at Marlboro, Vt. Some of the papers included are: Stationary Chippers for Processing Low-Quality and Waste Wood, Portable Wood Chipping Equipment, Pulpwood Operations, Roofing Material, Wallboard, Fuel.

Colloidal Dispersions. By Earl K. Fischer, National Bureau of Standards. John Wiley & Sons, Inc., New York, 1950. Cloth, 6 × 9, 387 pages. Illustrated. $7.50.

This is the first book to deal with both the theoretical and practical aspects of colloidal dispersions. Many paper and coating mill operations depend on many of the principles discussed. Among the subjects covered are particle size, the solid-liquid interface and wetting, rheological properties of dispersions, surface-active agents, the process of comminution, mixing, roll mills, ball and pebble mills and disk, cone and colloid mills. It is an excellent book of much practical value.

Sales and Business Forecasting in the Chemical Process Industries. By Robert S. Aries and William Copulsky. Chemonomics, Inc., New York, 1950. Paper-bound, $6^3/_4 \times 10^1/_4$, 132 pages. Photo-offset. $5.00.

The authors have had considerable experience in the field of market analysis, the value of which being to some extent a good guess of future prospects. A number of case studies are given, and although the text is largely in outline it indicates the approaches taken by the authors in dealing with specific objectives.

Note: Books reviewed in this department may be purchased through *Tappi*, 122 East 42nd Street, New York 17, N. Y.

EMPLOYMENT SERVICE

Positions Open

P136-51. An expanding organization has an opening in its product development department for a young man who has a B.S. or M.S. degree in chemical engineering and who graduated in the upper third of his class. This organization is a manufacturer and fabricator of unique fibrous and plastic materials.

P140-51. Long-established middle west manufacturer of specialty equipment for pulp and paper mills wishes to engage the services of a man who has knowledge of mill operation. Prefer man who has been selling to middle west and New England mills but will consider others possessing personality, education, and mill experience background who are interested in a position where initiative and aggressiveness will pay off in growing business. Work will consist of traveling about four months in the year, with balance of time devoted to working in home office handling correspondence with customers. Applicants should state age, education, marital status, and complete experience background in first letter.

P141-51. Graduate chemist to coordinate technical control in fine paper mill located in the middle west. Experience in rag papers desirable but not essential. Reply to Howard Paper Mills, Inc., 115 Columbia St., Dayton 7, Ohio.

P142-51. Opportunity for (1 chemist—B.S. or M.S.) (1 chemist—Ph.D.) (1 chemical engineer—B.S.) (1 chemical engineer—Ph.D.) and (1 physicist—M.S. or Ph.D.). Progressive and well-established manufacturing concern desires men for research and development work. Industrial or academic field, experience preferred, but not necessary. Applicants must have graduated in upper quarter of their class. Work will be individually assigned and problems are of stimulating nonroutine nature. Permanent positions with opportunities for advancement; ideal working conditions in well-equipped laboratory. Pleasant middle west town of 22,000, 1-hour drive from Columbus, Ohio. All inquiries will be held in strictest confidence. Write or telephone R. L. Warner, The Mead Corp., Chillicothe, Ohio.

P143-51. Sales engineer, chemical or mechanical, with experience in sulphate mill recovery operations and equipment. Reply should include personal data, résumé of experience, photograph, if available, and telephone number. Our employees know about this advertisement. Company located in the south.

P144-51. Technically trained papermaker to develop and market new paper products to utilize capacity of a paper machine. Experience with high-grade paper specialty products desirable. An excellent opportunity for a papermaker with imagination and technical knowledge in an integrated mill in the east now making book-paper grades.

P145-51. Chief Chemist. Young man, preferably with some teaching experience for large American newsprint mill in the east. Knowledge of groundwood, sulphite, and papermaking desirable.

P146-51. Chief Chemist or Technical Director. Coating mill in the middle west.

P147-51. Chemist for mid-west paper mill. Work involves deinking, stream pollution, surface application, etc. Opportunity for advancement. Experience necessary. Age 28–38 preferred.

Positions Wanted

E101-51. Chemical Engineer. 30, family, 5 years' diversified pulp and paper experience in control, engineering, and development in newsprint, sulphite, soda, groundwood, and waste papers. Presently employed. Desires position in production or production development. Prefers location in west or middle west.

E137-51. Cellulose research chemist with long experience in research or fundamental problems of constitution and properties of cellulose and woods; laboratory research and mill-scale experimental experience in dissolving and bleaching of soft and hardwood fibers for paper and dissolving purposes; seeks responsible position with academic or industrial organization.

E138-51. Assistant Manager with B.S. degree and 10 years' technical and executive experience which covers laboratory, mill control, scheduling and production of pulp and paper, and converting.

Note: In responding to employment service inquiries time will be saved if responses are addressed to the Technical Association of the Pulp and Paper Industry, 122 E. 42nd Street, New York 17, N. Y. Individuals are urged to include a carbon copy of their responses so that one can be kept on file for reference.

UNITED STATES PATENTS ON PAPERMAKING

First Quarter, 1951 ***Compiled by CLARENCE J. WEST***

The following list of United States patents has been compiled from the current numbers of the Official Gazette of the United States Patent Office. Because, as a rule, only one claim is published in the Gazette, it is not claimed that the list is complete; also, it is possible that the list may contain some patents that do not apply specifically to pulp and paper manufacture.

Copies of any of the following patents can be obtained from the United States Patent Office, Washington 25, D. C., by sending twenty-five cents for each patent desired.

January 2, 1951

2,536,018. Coating composition. Daniel Schoenholz and Herbert Terry, New York, N. Y. Filed June 16, 1948. 7 claims. (Cl. 117-38.) A composition containing polyvinyl acetate and various modifiers is proposed for coating paper book covers.

2,536,045. Producing alpha cellulose from cottonseed hull fibers. Jefferson L. Eskridge, Long Island City, N. Y. Filed July 17, 1945. 12 claims. (Cl. 92-13.) Fibers are digested for 1 to 3 hours at 160°C. and 109 p.s.i. with a liquor having the composition (based on the weight of the air-dry hull fiber): 600% water, 10% sodium hydroxide, 0.417% ammonium hydroxide (26° Bé.), 0.625% potassium carbonate, and 0.2085% ammonium oxalate.

2,536,046. Alkaline digestion of cottonseed hulls. Jefferson L. Eskridge, Long Island City, N. Y. Filed July 17, 1945. 6 claims. (Cl. 92-13.) Premoistened hulls are digested at 52 to 135 p.s.i. and 171°C. with a solution containing 360 pounds of sodium hydroxide, 15 pounds of ammonium hydroxide (26° Bé.), 22.5 pounds of potassium carbonate, 7.5 pounds of ammonium oxalate, and 10,000 pounds of water per ton of air-dry hulls.

2,536,047. Alkaline digestion of cottonseed hull bran. Jefferson L. Eskridge, Long Island City, N. Y. Filed July 27, 1945. 7 claims. (Cl. 92-13.) Cottonseed hull bran from which substantially all cotton fuzz has been removed is heated with an alkaline liquor at 300 to 350°F. in a closed vessel until about 20% of the hull bran constituents are dissolved.

2,536,049. Coating composition. William F. Flanagan, assignor to New Wrinkle, Inc., Dayton, Ohio. Filed Aug. 20, 1948. 4 claims. (Cl. 260-31.8.) The coating agent is a vinyl chloride–vinyl acetate copolymer in a suitable solvent.

2,536,107. Coating composition and method of using same. Nathan Sugarman and Foster Fryman, assignors to The Standard Register Co., Dayton, Ohio. Filed Jan. 16, 1947. 14 claims. (Cl. 117-62.) A quick-setting composition for the coating of carbon paper consists principally of heat-polymerized furfural and tetrahydrofurfuryl phthalate with various modifiers.

2,536,285. Process of making high wet strength paper. Herman C. N. Heckel and Arthur C. Salisbury, assignors to The Champion Paper and Fibre Co., Hamilton, Ohio. Filed July 25, 1946. 9 claims. (Cl. 8-116.) Paper is exposed to nitrogen dioxide, the excess is removed, and the paper is washed with water until free from acid. The time of exposure is adjusted so that the carboxyl content of the paper is less than 1% and the nitrogen content less than 0.2%.

2,536,332. Apparatus for refining fibrous materials. Henri L. X. Vincent, Malines, Belgium. Filed Oct. 20, 1947. 1 claim. (Cl. 92-26.) A pulp refiner comprises a rotary, cylindrical, supporting, and refining surface for the pulp, as well as a number of grooved rollers; the grooves are substantially perpendicular to the axis of rotation. The pulp is passed successively between the roughened inner surface of the rotating cylinder and each of the rollers.

2,536,384. Glueless interlock for double walled folding boxes. Reginald B. Meller, assignor to Bemiss-Jason Co., San Francisco, Calif. Filed April 17, 1948. 21 claims. (Cl. 229-35.) A glueless interlock for multiwall folding boxes is permanent and cannot, except by the use of special tools, be separated or disengaged.

2,536,442. Container. Reynolds Guyer, assignor to Waldorf Paper Products Co., St. Paul, Minn. Filed Jan. 27, 1949. 3 claims. (Cl. 229-23.) The patent covers the construction of a paperboard storage battery container.

2,536,446. Suction box for traveling screen filters. Irving C. Jennings, South Norwalk, Conn. Filed Feb. 2, 1946. 10 claims. (Cl. 40-197.) A suction box for a fourdrinier machine is equipped with small diameter rollers and is provided with means for supporting the rollers at frequent intervals to prevent their deflection.

2,536,529. Method of producing bags with opening means. Samuel Bergstein, Cincinnati, Ohio, assignor to Robert M. Bergstein and Frank D. Bergstein, trustees. Filed Aug. 9, 1944. 4 claims. (Cl. 93-35.) A bag machine is adapted for the manufacture of laminated bags or carton liners—e.g., those from Pliofilm laminated to paper.

2,536,530. Overlapped-end box. Samuel Bergstein, Cincinnati, Ohio, assignor to Robert M. Bergstein and Frank Bergstein, trustees. Filed Dec. 7, 1946. 10 claims. (Cl. 229-31.) An overlapped-end paperboard box is provided with a positive locking means for the inturned flap.

2,536,587. Pallet. George E. Whalley, Detroit, Mich. Filed April 10, 1946. 1 claim. (Cl. 248-120.) A pallet consists of a number of relatively flat, hollow sections, each formed by wrapping a sheet of phenolic resin-impregnated material around a core and removing the core after the resinous material is cured.

2,536,590. Stiff paper basket. Guenther C. F. Brandes, Barrington, Ill. Filed Dec. 28, 1946. 4 claims. (Cl. 229-3.5.) The construction of the basket is described.

2,536,639. Poultry tray. Reynolds Guyer, assignor to Waldorf Paper Products Co., St. Paul, Minn. Filed Nov. 29, 1946. 8 claims. (Cl. 206-44.) A cardboard poultry tray is claimed.

2,536,656. Method of waterproofing paper textile fabrics. John J. Petroske, assignor to Patchogue-Plymouth Mills Corp., New York, N. Y. Filed July 13, 1945. 3 claims. (Cl. 117-68.) The waterproofing agent is aluminum acetate in a wax emulsion; the method of application is described.

2,536,675. Method and means of making bags. Samuel Bergstein, Cincinnati, Ohio, assignor to Robert M. Bergstein and Frank D. Bergstein, trustees. Filed May 7, 1945. 3 claims. (Cl. 93-18.)

2,536,834. Ham packaging bag. James A. Baker, Milwaukee, Wis., and Frank A. Hunter, Jr., Clayton, Mo. Filed Nov. 3, 1947. 3 claims. (Cl. 229-55.) The bag consists of an inner layer of grease-resistant stock, an intermediate layer of heavier moisture-absorbent stock (e.g., light cardboard), and an outer layer of durable, colored, printed stock.

2,536,885. Method of making multiconductor cables. John W. Olson, assignor to Anaconda Wire and Cable Co., New York, N. Y. Filed April 21, 1948. 7 claims. (Cl. 154-2.24.) The paper wrapping is precoated with a thermoplastic material (e.g., a bituminous composition).

2,536,946. Shower assembly for papermaking machines. Oscar E. Larson, assignor to John W. Bolton & Sons, Inc., Lawrence, Mass. Filed Nov. 21, 1945. 2 claims. (Cl. 299-59.) A device for cleaning a shower pipe is claimed.

2,536,948. Carton. Lincoln D. Lehman, Portland, Ore. Filed Jan. 15, 1947. 2 claims. (Cl. 229-31.) A closure for a one-piece heat- and cold-insulating carton is claimed.

2,536,990. Folding box. Marshall I. Williamson, assignor to National Folding Box Co., Inc., New Haven, Conn. Filed Jan. 29, 1948. 8 claims. (Cl. 229-37.) A folding display box is provided with an integral main panel for the support of merchandise.

January 9, 1951

2,537,017. Coating compositions. Gerald R. Barrett, assignor to Monsanto Chemical Co., St. Louis, Mo. Filed May 29, 1948. 14 claims. (Cl. 260-45.2.) A coating composition for paper and the like comprises polyvinyl butyral and the copolymerization product of styrene and half esters of maleic acid.

2,537,019. Coating compositions. Gerald R. Barrett, assignor to Monsanto Chemical Co., St. Louis, Mo. Filed May 29, 1948. 12 claims. (Cl. 260-45.2). The coating agent consists of a methylisobutylcarbinyl acid maleate and styrene copolymer and a lesser quantity of a methylated malamine-formaldehyde resin in a suitable solvent.

2,537,101. Process for manufacture of wallboard from lignocellulosic material. Warren R. Smith, Crown Point, N. Y., and Donald F. Othmer, Coudersport, Pa. Filed June 8, 1946. 3 claims. (Cl. 260-17.2.) A mixture of a phenol and lignin

with wood waste is heated at 178 to 300°C. and at least 150 p.s.i.

2,537,114. Pigment coated paper. Arthur E. Young and Elmer K. Stilbert, assignors to The Dow Chemical Co., Midland, Mich. Filed Feb. 26, 1948. 9 claims. (Cl. 117-155.) A printing paper is coated with a mixture of 8 to 30 parts of adhesive and 100 parts of clay; the adhesive consists of soybean protein and 0.333 to 3 parts of a butadiene-styrene copolymer (40: 60) per part of protein.

2,537,129. Structure for web transfers. John E. Goodwillie, assignor to Beloit Iron Works, Beloit, Wis. Filed Oct. 5, 1945. 4 claims. (Cl. 92-49.) A paper machine is provided with a suction transfer roll for transferring a moist paper web from a pickup felt to a drier felt without the direct application of roll pressure to the felt at the point of transfer.

2,537,151. Carton for packaging radio tubes and like articles. Joseph E. Mires, assignor to Somerville Ltd., London, Ont., Canada. Filed Sept. 12, 1946. 1 claim. (Cl. 229-39.)

2,537,318. Collapsible recessed display stand. William H. Scoble, assignor to Einson-Freeman Co., Inc., Long Island City, N. Y. Filed July 22, 1949. 2 claims. (Cl. 211-135.) A cardboard merchandise-display table.

2,537,374. Egg carton. Louis Schwartzberg, Chicago, Ill. Filed Feb. 3, 1947. 2 claims. (Cl. 229-29.) Construction is described.

2,537,414. Screening drum for dewatering suspensions. Karl R. Lindblad, assignor to Svenska Cellulosa Aktiebolaget, Stockholm, Sweden. Filed Feb. 4, 1946. 5 claims. (Cl. 92-42.) The drum for dewatering pulp consists of an outer shell with screen openings and an inner shell without such openings. The space between the shells is divided into cells which communicate with the interior of the drum through a discharge duct.

2,537,452. Bottle carrier. Homer W. Forrer, assignor to Atlanta Paper Co., Atlanta, Ga. Filed June 26, 1948. 11 claims. (Cl. 229-52.) The construction of a collapsible bottle carrier is claimed.

2,537,462. Method of making automatic bottom bags. Alfred B. Haslacher, San Francisco, Calif. Filed Nov. 16, 1944. 9 claims. (Cl. 93-35.) The mouth structure of a two-ply gusseted paper bag incorporates an inner ply of heat-fusible material.

2,537,464. Paper roll breaker. John A. Holmberg, assignor to Crown Zellerbach Corp., San Francisco, Calif. Filed Aug. 31, 1948. 10 claims. (Cl. 164-84.5.) A machine is designed for breaking apart and separating small individual rolls of paper (e.g., toilet paper) after they have been cut from longer rolls.

2,537,492. Expansible winder shaft. Edward H. Tidland, Camas, Wash. Filed July 26, 1949. 5 claims. (Cl. 242-72.) A winder shaft is adapted to be expanded pneumatically and to be contracted quickly by the deflation of a rubber tube within the shaft.

2,537,509. Process for making wallboard. Thomas P. Camp, assignor to United States Gypsum Co., Chicago, Ill. Filed Dec. 20, 1944. 5 claims. (Cl. 154-87.) The manufacture of paper-lined gypsum wallboard is described.

2,537,614. Bottle carrier. Edwin L. Arneson, assignor to Morris Paper Mills, Chicago, Ill. Filed Aug. 30, 1947. 13 claims. (Cl. 224-45.) A compartmented paperboard bottle carrier incorporates a multi-ply central handle member.

2,537,615. Bottle carrier. Edwin L. Arneson, assignor to Morris Paper Mills, Chicago, Ill. Filed Jan. 11, 1949. 8 claims. (Cl. 229-52.) The carrier has incorporated in its end walls integral flap elements which are interleaved and adhesively attached to a central vertical panel.

2,537,617. Single blank cloth board end cap. Walter A. Becker and Carl P. Cato, assignors to Old Dominion Box Co., Lynchburg, Va. Filed Aug. 26, 1947. 1 claim. (Cl. 229-16.) A foldable board blank is adapted to slip over each end of a corrugated bolt board.

2,537,764. Apparatus for slitting and expanding sheet material. Dean L. Hunzicker and Clifford T. Walton, assignors to Research Products Corp., Madison, Wis. Filed Aug. 21, 1946. 17 claims. (Cl. 93-1.) An apparatus is provided for slitting thin flexible sheet material which is then adapted to be expanded by a stretching operation.

2,537,874. Machine for producing display cards. John Aquilla, Brooklyn, N. Y. Filed Dec. 18, 1946. 7 claims. (Cl. 154-1.8.) The machine is designed for the manufacture of tissue-covered jewelry display cards.

2,537,801. Fastening device. Michael J. Swatsick, assignor to Stanley De Mian, Chicago, Ill. Filed April 27, 1946. 2 claims. (Cl. 229-47.) A fastening device for a box with an open top and provided with a hand hole in the wall.

January 16, 1951

2,538,002. Container for and process of preserving perishable foodstuffs. Carroll R. Irons and George W. Stanton, assignors to The Dow Chemical Co., Midland, Mich. Filed Nov. 29, 1947. 1 claim. (Cl. 229-53.) A flexible bag is formed of a copolymer of from 90 to 92% vinylidene chloride and 8 to 10% of acrylonitrile.

2,538,025. Container for and process of preserving perishable foodstuffs. Garnett V. Moore and Carroll R. Irons, assignors to The Dow Chemical Co., Midland, Mich. Filed Nov. 29, 1947. 2 claims. (Cl. 229-53.) The container is formed of a copolymer of from 70 to 77% vinylidene chloride and 23 to 30% vinyl chloride.

2,538,086. Machine for pressing sheet material. Robert C. Dennison, Manchester, Conn. Filed Feb. 5, 1947. 3 claims. (Cl. 92-71.) The patent covers a calender for paperboard.

2,538,103. Method of separating fatty acids from rosin acids of tall oil. Samuel D. Koonce and Edmond S. Perry, assignors to Eastman Kodak Co., Rochester, N. Y. Filed Nov. 9, 1946. 7 claims. (Cl. 260-97.6.) The rosin acids in tall oil are reacted with maleic anhydride at 150–210°C. to form solid adducts. The fatty acid fraction is separated by distillation.

2,538,302. Lignin-furfuryl alcohol resins and process of making same. Raymone N. Evans and Angelo P. Ingrassia, assignors to Masonite Corp., Laurel, Miss. Filed June 3, 1946. 4 claims. (Cl. 260-17.4.) A resin formed from furfuryl alcohol and lignin with an acid catalyst is mixed with exploded wood chips and formed into a board with heat and pressure.

2,538,383. Antisurge valve for hydraulic wood grinders. Percy R. Sandwell, Vancouver, B. C., Canada. Filed Sept. 23, 1948. 5 claims. (Cl. 121-46.5.)

2,538,397. Manufacture of coated water-vaporproof paper and coating compositions. Alexander Szwarc, Montreal, Que., Canada. Filed March 6, 1948. 2 claims. (Cl. 260-17.) The principal constituents are a polymerized coumarone-indene resin, ethylcellulose, the methyl ester of rosin and its hydrogenated derivative, paraffin wax, and a polymer of isobutene.

2,538,510. Bag closure. James F. Doyle, assignor to Arkell Safety Bag Co., New York, N. Y. Filed Jan. 4, 1945. 4 claims. (Cl. 229-62.) A method is described for forming a sewed seam-type closure for multiwall paper bags.

2,538,585. Bag closure. Gösta K. Odén, Nybro, Sweden. Filed Feb. 26, 1948. 3 claims. (Cl. 229-62.) A method of forming a nonsifting closure for a paper bag is described.

2,538,742. Digesting lignocellulose with a rosin soap. Grant S. Wiley, assignor to United States Gypsum Co., Chicago, Ill. Filed Feb. 14, 1944. 6 claims. (Cl. 92-6.) Lignocellulosic material (e.g., cottonwood or willow) is digested at 335 to 385°F. for 0.5 to 1.5 hours in an aqueous suspension of a waterproofing sizing material (e.g., rosin size); the product is stated to form a high-strength, water-resistant hardboard with improved bending properties.

January 23, 1951

2,538,802. Method of manufacturing calcium carbonate. Milton O. Schur and Robert M. Levy, assignors to Ecusta Paper Corp., New York, N. Y. Filed May 3, 1947. 4 claims. (Cl. 23-66.) A calcium carbonate suitable for cigarette paper is formed by precipitation of calcium carbonate in the presence of a suspension of previously produced carbonate of fine particle size.

2,538,860. Automatic set-up box. Kenneth T. Buttery, assignor to Sutherland Paper Co., Kalamazoo, Mich. Filed Sept. 23, 1948. 7 claims. (Cl. 229-44.) A set-up box is automatically erected by pressure on opposite ends of the collapsed carton. A stable bottom is provided and the walls are supported against racking stresses.

2,538,920. Display bag and method of making the same. Harold F. Shumann, Pittsburgh, Pa. Filed Nov. 18, 1946. 2 claims. (Cl. 229-53.) A display bag is formed from heat-sealing cellophane or coated, heat-sealable glassine paper.

2,538,926. Method of making waterproof fibrous containers. Daniel M. Sutherland, Morrisville, Pa. Filed March 25, 1946. 2 claims. (Cl. 18-47.5.) An aqueous suspension of wet powdered gilsonite is incorporated in a pulp stock to be used for the manufacture of containers.

2,538,946. Metal closure for powder cans. Robert Nyden and Harry K. Dickerman, assignors to F. N. Buty Co., Inc., Buffalo, N. Y. Filed July 6, 1945. 1 claim. (Cl. 229-5.5.)

2,539,093. Nitric acid digestion of straw. Henri Mainguet, Paris, France. Filed Jan. 6, 1945. 3 claims. (Cl. 92-9.) Straw is impregnated with nitric acid (2 to 3.3 grams of acid per liter) at 15 to 40°C. and then heated in about 15 minutes to a temperature of 73 to 83°C.

2,539,183. Method of making moisture-resistant paper. Chester M. Child, Methuen, Mass. Filed Nov. 29, 1944. 5 claims. (Cl. 92-21.) The sizing agent is rosin and microcrystalline wax; the wax is bonded to the fibers by a urea-formaldehyde resin.

2,539,304. Bottle carrier. Maynard G. Hall and Michael H. Kowal, assignors to Empire Box Corp., Garfield, N. J. Filed May 6, 1948. 5 claims. (Cl. 229-28.) The end panels of a multicompartment bottle carrier project from opposite ends of the folded carrier.

2,539,356. Apparatus for making fluted containers. Melvin

H. Sidebotham, Winchester, Mass. Filed Dec. 11, 1947. 2 claims. (Cl. 154-30.) A corrugating machine for the high-speed production of a continuous series of transversely positioned fluted units from two paper webs.

January 30, 1951

2,539,389. Sealing head mechanism for closing and sealing bags and containers. August E. Almgren and John P. Jakob, assignors to American Can Co., New York, N. Y. Filed Dec. 17, 1947. 11 claims. (Cl. 93-6.) The marginal edge portions of a bag are folded in such a manner that corner pleats are formed.

2,539,390. Method of sealing bags. August E. Almgren and John P. Jakob, assignors to American Can Co., New York, N. Y. Filed Dec. 17, 1947. 5 claims. (Cl. 93-6.) The marginal edge portions of a bag are folded in such a manner that corner pleats are formed.

2,539,450. Method of producing fiber tubing. Donald G. Magill, assignor to American Can Co., New York, N. Y. Filed Nov. 21, 1946. 6 claims. (Cl. 93-80.) A fluid (e.g., a mineral oil) is applied to a single-ply web, which is wound to form an inner layer of sheet material with overlapped inner seams, various layers being united with an adhesive. The product is used for forming containers.

2,539,558. Permanent paper and method of making same. John Studeny, John D. Pollard, and Chester G. Landes, assignors to American Cyanamid Co., New York, N. Y. Filed Sept. 28, 1948. 5 claims. (Cl. 117-154.) Paper is impregnated with a 1 to 5% aqueous solution of dicyandiamide or a derivative to retard its embrittlement and discoloration.

2,539,658. Knockdown chest. Harry Derman, Great Neck, N. Y. Filed Feb. 7, 1946. 10 claims. (Cl. 229-23.) A chest for storage of children's toys.

2,539,767. Method of making a filter element. Louis E. Anderson, assignor to The Cuno Engineering Corp., Meriden, Conn. Filed May 5, 1947. 6 claims. (Cl. 92-57.) A method is given for the manufacture of thick-walled filter elements by an accretion process.

2,539,799. Bag closure. Wolfgang O. Streller, assignor to St. Regis Paper Co., New York, N. Y. Filed April 14, 1948. 2 claims. (Cl. 229-62.) An end closure for a valve-type bag incorporates a sealing tape which overlaps the end of the bag.

2,539,975. Process for improving the drying qualities of tall oil. William C. Spitzer and Russell T. Ryan, assignors to The Sherwin-Williams Co., Cleveland, Ohio. Filed Oct. 14, 1948. 11 claims. (Cl. 260-97.5.) Crude tall oil acids or their polyhydric alcohol esters are heated to 200 to 300°C. and blown with air.

2,540,065. Carrier for bottles, cans, or similar articles. Marshall I. Williamson, assignor to National Folding Box Co., Inc., New Haven, Conn. Filed March 30, 1949. 6 claims. (Cl. 224-48.)

2,540,066. Bottle carrier. Marshall I. Williamson, assignor to National Folding Box Co., Inc., New Haven, Conn. Filed March 30, 1949. 6 claims. (Cl. 224-48.)

2,540,067. Carrier for bottles, cans, or similar articles. Marshall I. Williamson, assignor to National Folding Box Co., Inc., New Haven, Conn. Filed March 30, 1949. 9 claims. (Cl. 224-48.)

2,540,068. Wire handles for bottle carriers. Marshall I. Williamson, assignor to National Folding Box Co., Inc., New Haven, Conn. Filed March 30, 1949. 2 claims. (Cl. 224-48.)

February 6, 1951

2,540,301. Papermaking machine and control therefor. Stephen A. Staege, assignor to The Black-Clawson Co., Hamilton, Ohio. Filed July 30, 1945. 8 claims. (Cl. 92-43.) This covers a stock consistency regulator.

2,540,321. Dispensing container. Robert B. Cartwright, Peoria, Ill. Filed June 28, 1947. 4 claims. (Cl. 229-7.) A paperboard cereal carton, equipped with a pouring spout.

2,540,342. Food container. David J. Moore, Chicago, Ill. Filed June 4, 1946. 3 claims. (Cl. 229-23.) A container for oleomargarine divided into two half-pound compartments.

2,540,352. Method of making wet strength paper. Willard A. Schenck, assignor to Munising Paper Co., Munising, Mich. Filed Oct. 27, 1945. 8 claims. (Cl. 117-155.) Paper is impregnated with a solution containing self-polymerized ω-aminocaproic acid, oxalic acid, and formaldehyde.

2,540,517. Paper stock screening apparatus. Mark A. Glasco, Middletown, Ohio. Filed May 11, 1948. 3 claims. (Cl. 92-20.) The first stage of the screening operation takes place in a primary chamber where the relatively large particles of foreign matter are separated by gravity and the second occurs on the forminous top or screen of a secondary chamber where the relatively small light particles are separated by the vibrating action of the chamber and screen.

2,540,565. Double-wall paper container. Cesare Barbieri, assignor to Dixie Cup Co., Chicago, Ill. Filed Feb. 27, 1947. 3 claims. (Cl. 229-5.5.) A double-wall, double-bottom paper cup for hot or cold liquids, etc.

2,540,595. Carton. George P. Props, assignor to Fort Wayne Corrugated Paper Co., Fort Wayne, Ind. Filed May 22, 1948. 1 claim. (Cl. 229-23.) A carton for fruit.

2,540,707. Florist's pack and jacket for the same. Henry Beukelman, Camden, Me. Filed Oct. 30, 1945. 6 claims. (Cl. 229-21.) A flower pot jacket.

2,540,712. Container bottom structure. John H. Cassidy and Reed M. Grunden, assignors to The Hinde & Dauch Co., Sandusky, Ohio. Filed July 28, 1948. 3 claims. (Cl. 229-39.) The bottom is so constructed as to hold the upright walls of the container square and to distribute effectively the loads imposed upon the bottom to the side walls.

2,540,874. Felt for papermaking machines. Saint J. Geddings, Columbia, S. C. Filed May 25, 1949. 1 claim. (Cl. 139-411.) One face of the felt is formed of asbestos and the other of cotton.

2,540,978. Refining of vegetable wax powder. Alfred F. Buckman, Jr., assignor to S. C. Johnson & Son, Inc., Racine, Wis. Filed May 15, 1948. 10 claims. (Cl. 209-173.) In the purification of crude waxes, sodium lignosulphonate is used as a wetting agent.

February 13, 1951

2,541,058. Processing of lignocellulose materials. Clark C. Heritage and William G. Van Beckum, assignors to Wood Conversion Co., Cloquet, Minn. Filed June 16, 1948. 25 claims. (Cl. 260-124.) Wood is treated with 0.6% aqueous sodium hydroxide at 20 to 140°C.; the product is extracted with water and separated from the fibrous residue; the extract is treated with sulphuric acid to precipitate the lignin.

2,541,059. Process for producing lignin products. Clark C. Heritage and William G. Van Beckum, assignors to Weyerhaeuser Timber Co., Longview, Wash. Filed June 17, 1948. 8 claims. (Cl. 260-124.) Wood, agricultural residues, and the like are extracted with sodium hydroxide, from which extract lignin products can be separated.

2,541,127. Process for producing dehydroperillic acid. William G. Van Beckum, assignor to Weyerhaeuser Timber Co., Longview, Wash. Filed June 17, 1948. 6 claims. (Cl. 260-124.) Wood is extracted with 0.06% aqueous sodium hydroxide, from which by a fractionation procedure dehydroperillic acid and lignin fractions can be separated.

2,541,173. Package. George A. Moore, assignor to National Biscuit Co., New York, N. Y. Filed Nov. 2, 1943. Only 14 claims. (Cl. 229-23.) A tray for crackers and the like is coated on its inner surface with a nitrocellulose or ethylcellulose lacquer.

2,541,258. Folded blank container for cigarettes and the like. Louis I. Lane, Miami Beach, Fla. Filed Sept. 2, 1948. 3 claims. (Cl. 229-27.) A dual-compartment container is formed from a single sheet of cardboard.

2,541,368. Carton for cushioned shipping and displaying fragile articles. Irving I. Kloner, Brooklyn, N. Y. Filed Sept. 5, 1947. 13 claims. (Cl. 229-27.) Cushioning means are used to protect fragile articles, such as a glass- or mirror-paneled vanity case.

2,541,414. Box-making machine. Harold J. Goss, assignor to Central National Bank of Cleveland, Cleveland, Ohio. Filed May 31, 1946. 21 claims. (Cl. 93-49.) A machine for the manufacture and erection of double-wall boxes, which permits a desired number of boxes to be delivered simultaneously and in sequence to a conveyor.

2,541,692. Paper size. August S. Erspamer, assignor to P. H. Glatfelter Co., Spring Grove, Pa. Filed Jan. 14, 1947. 10 claims. (Cl. 260-26.) The size is an aqueous alkaline dispersion of a mixture of rosin and an ester of glycerol and maleic anhydride.

2,541,905. Apparatus for rimming paper cups. Stephen W. Amberg, assignor to Lily-Tulip Cup Corp., New York, N. Y. Filed Feb. 6, 1947. 4 claims. (Cl. 93-36.5.)

2,541,914. Carton folding machine. Hugh F. Conser, assignor to Shedd-Bartush Foods, Inc., Detroit, Mich. Filed May 14, 1945. 2 claims. (Cl. 93-49.) A machine for closing the end of a carton.

February 20, 1951

2,542,025. Method of pressing sheet lumber. Worth C. Goss, assignor to Edward S. Heller, Seattle, Wash. Filed July 1, 1946. 6 claims. (Cl. 18-47.5.) A method is described for forming boards from wood waste and a bonding agent by heating under pressure.

2,542,060. Method of recovering chemicals from liquor produced by pulping of cellulosic materials. Herman N. Simpson, Seattle, Wash. Filed Jan. 2, 1945. 15 claims. (Cl. 23-179.) A method is proposed for the combustion of calcium-base sulphite liquor.

2,542,099. Boxmaking system. John S. Stokes, assignor to

Stokes and Smith Co., Philadelphia, Pa. Filed Jan. 16, 1946. 7 claims. (Cl. 92-54.) A method of covering a box blank with a wrapper.

2,542,139. Machine for laminating and reinforcing webs. Jack W. Holland, Hopatcong, N. J. Filed May 25, 1949. 2 claims. (Cl. 154-1.7.) A machine is designed for the simultaneous production of two two-ply laminated paper webs with transverse reinforcing filaments between the plies.

2,542,170. Method of adhesively securing valve sleeves to bags. Norman E. Weeks, assignor to Bemis Bro. Bag Co., St. Louis, Mo. Filed Oct. 9, 1948. 2 claims. (Cl. 154-116.) A paper valve sleeve is coated with a transverse tripe of thermoplastic adhesive, which serves to unite the sleeve to a cloth bag.

2,542,180. Dispensing container for matches. Raymond Chemlinski, Schenectady, N. Y. Filed June 8, 1945. 2 claims. (Cl. 229-17.) The container has two triangular edge sections which can be removed to provide access to the merchandise.

2,542,214. Card or license receiving envelope and tag. Lester L. Sherwood, Banning, Calif. Filed Oct. 8, 1948. 3 claims. (Cl. 229-74.)

2,542,245. Cooking bag. Herman Gottesman, Ramsey, N. J. Filed March 23, 1946. 4 claims. (Cl. 229-62.) The walls of a bag of vegetable parchment are secured at the edges by heavy reinforcements.

2,542,287. Drying drum. Herman E. Neubauer, assignor to Blaw-Knox Co., Buffalo, N. Y. Filed Nov. 6, 1945. 3 claims. (Cl. 34-124.) The construction of a steam-heated drier drum is claimed.

2,542,298. Method and apparatus for making laminated packaging blanks. Julius A. Zinn, Jr., Chicago, Ill. Filed Feb. 3, 1948. 14 claims. (Cl. 93-36.6.) A cardboard and a metal foil, waxed paper, or the like are laminated (method given), the product being suitable for a food or beverage container.

2,542,299. Brightness meter. Hugh M. Archer and Howard A. Boltz, assignors to General Electric Co., Schenectady, N. Y. Filed Dec. 2, 1948. 2 claims. (Cl. 250-214.)

2,542,344. Back-sizing composition for floor coverings, Emory P. Mersereau, Jr., assignor to Alexander Smith & Sons Carpet Co., Yonkers, N. Y. Filed March 11, 1947. 2 claims. (Cl. 106-123.) The composition contains 28 to 50% sulphite waste liquor solids, 20 to 35% starch, 0 to 42% mineral filler, and 8 to 23% plasticizing resin.

2,542,371. Hydraulic log barker with self-lubricating sealing means. Frank H. Swift and Guy R. Dodson, assignors to Crown Zellerbach Corp., San Francisco, Calif. Filed April 8, 1946. 4 claims. (Cl. 144-208.) A seal is lubricated by the same water that is employed for barking purposes.

2,542,379. Container folding machine. Louis Veyret and Georges Geffroy, assignors to La Cellophane, Paris, France. Filed Jan. 20, 1948. 6 claims. (Cl. 93-49.)

2,542,504. Carton. Joseph Gariepy, Everett, Mass. Filed March 1, 1949. 2 claims. (Cl. 229-28.) A multicompartmented cardboard carton is adapted for packing fragile articles, such as eggs, Christmas tree ornaments, and the like.

2,542,721. Fire retardant waterproof coating. Robert M. Stafford, assignor to Johns-Manville Corp., New York, N. Y. Filed Jan. 25, 1947. 2 claims. (Cl. 106-15.) A coating for asbestos roofing sheets consists of asphalt containing uniformly distributed cellular perlite.

2,542,801. Continuous digestion apparatus for the production of highly purified cellulose. Joaquin J. de la Roza, Sr., New York, N. Y. Filed April 12, 1945. 4 claims. (Cl. 92-11.) The apparatus consists of successive digesters which comprise inclined concentric vessels (the inner one rotary and the outer stationary) and an internal open screw which is affixed to the inner wall of the rotary vessel.

February 27, 1951

2,543,084. Sealed container with hinged cover. Marshall I. Williamson and Herman A. Carruth, assignors to National Folding Box Co., Inc., New Haven, Conn. Filed Sept. 19, 1945. 7 claims. (Cl. 229-45.) A hinged-cover paperboard contained comprises a self-contained box part and a hinged cover part which telescopes over one end of the box portion.

2,543,128. Outfeeding mechanism for portable debarking machine. Michael J. Power, assignor to Nekoosa Foundery and Machine Works, Inc., Nekoosa, Wis. Filed Feb. 7, 1947. 6 claims. (Cl. 144-247.)

2,543,258. Pencil box. David Primak. Brooklyn, N. Y. Filed March 22, 1949. 1 claim. (Cl. 229-47.)

2,543,275. Foldable carton. Oscar A. Berman, New York, N. Y. Filed April 4, 1949. 9 claims. (Cl. 206-7.) A container for suits, dresses, and the like.

2,543,376. Valve. Perry S. Pine, assignor to Noble & Wood Machine Co., Hoosick Falls, N. Y. Filed Sept. 3, 1947. 2 claims. (Cl. 251-10.) A dump valve for a beater.

2,543,525. Conductor guide in insulating machine. Waldemar C. Ewaldson, assignor to Western Electric Co., Inc., New York, N. Y. Filed April 16, 1947. 3 claims. (Cl. 92-40.) The guide is readily variable with respect to a fourdrinier wire to which pulp is applied to cover a number of parallel electrical conductors and is responsive to the variations in the gage of the conductors.

2,543,698. Handle for bottle carrier. Samuel N. Lebold, assignor to Morris Paper Mills, Chicago, Ill. Filed June 14, 1946. 4 claims. (Cl. 224-48.)

March 6, 1951

2,543,757. Sealed carton and method. Frank D. Bergstein, Cincinnati, Ohio. Filed Aug. 12, 1947. 9 claims. (Cl. 229-5.5). A wax-sealed paperboard frozen food container.

2,543,821. Article carrier. Edwin L. Arneson, assignor to Morris Paper Mills, Chicago, Ill. Filed June 30, 1950. 1 claim. (Cl. 229-52.) A carrier adapted for two large-size bottles, which has a two-ply medial partition and a carrying handle.

2,543,858. Fungicidally treated multiwall bag. Frank R. Linda, assignor to St. Regis Paper Co., New York, N. Y. Filed April 9, 1948. 11 claims. (Cl. 229-55.) The innermost ply of a multiwall paper bag designed for citrus fruits is impregnated with a paraffin or other mineral wax which incorporates a fungicidal agent such as diphenyl.

2,543,870. Suction box cover for papermaking machines. Douglas R. Robbins, Middletown, Ohio. Filed Dec. 10, 1947. 7 claims. (Cl. 92-51.) The evacuation slots of a suction box cover are echeloned; the echelons are so arranged that any possible lateral thrust of the fourdrinier wire is neutralized.

2,544,019. Manufacture of plastic-fiber composition. Clark C. Heritage, assignor to Wood Conversion Co., St. Paul, Minn. Filed June 21, 1945. 8 claims. (Cl. 154-101.) A mat of vegetable fibers and solid heat-softenable binder is formed on a moving conveyor and the mat is hot molded.

2,544,020. Method and machine for making and filling fluted containers. Roderick W. Hoag, Melrose, Mass. Filed Sept. 2, 1948. 13 claims. (Cl. 93-3.) A method of forming shaker-dispenser packaging units from a web of single-fluted corrugated material.

2,544,054. Valve structure and system therefor. Judson P. Smith, assignor to Wood Conversion Co., St. Paul, Minn. Filed Dec. 2, 1946. 10 claims. (Cl. 302-17.) A valve for an apparatus for conveying solid material in gaseous suspension.

2,544,101. Box. John H. Oxley, Watertown, Mass. Filed July 24, 1946. 1 claim. (Cl. 229-23.)

2,544,146. Adhesive composition for metal foil to paper laminating. Carl R. Erikson, assignor to The Arabol Mfg. Co., New York, N. Y. Filed March 29, 1949. 3 claims. (Cl. 260-8.) The principal constituents are polyvinyl acetate resin, casein, and ammonia.

2,544,199. Machine for dipping bags. Edric W. Vredenburg, assignor to St. Regis Paper Co., New York, N. Y. Filed Feb. 14, 1946. 7 claims. (Cl. 91-46.) An apparatus for dipping bags in molten wax.

2,544,279. Tympan. William Page, assignor to Swigart Paper Co., Chicago, Ill. Filed July 24, 1948. 6 claims. (Cl. 154-54.5.) A washable tympan consists of a sheet of paper of great tensile strength and a sheet of parchment paper laminated with starch and a resin.

2,544,283. Reusable container. Leonard W. Snyder, assignor to Container Corp. of America, Chicago, Ill. Filed April 20, 1948. 8 claims. (Cl. 229-32.) A reusable container for bottles, bread, bananas, and the like is held in the set-up condition by a metal rim around its upper edges.

2,544,501. Cigarette container. Gene Johnson, Westchester County, N. Y. Filed April 11, 1947. 3 claims. (Cl. 206-41.2.)

2,544,509. Method of making paper containers greaseproof. Ralph H. McKee, New York, N. Y. Filed Nov. 17, 1944. 5 claims. (Cl. 226-19.) The inner wall of the container is coated with low-viscosity glue and with 0.2 to 0.5% (based on the glue) of hexamethylenetetramine; the glue is hardened by the formaldehyde liberated from the tetramine.

2,544,557. Oscillating doctor for paper machines. William Lyon, assignor to Messrs. Walmsleys (Bury) Ltd., Bury, England. Filed Aug. 27, 1947. 9 claims. (Cl. 92-74.)

2,544,565. Collapsible carton. Lawrence H. Phillips, assignor to O. B. Andrews Co., Chattanooga, Tenn. Filed Oct. 28, 1949. 3 claims. (Cl. 229-33.) A container for frozen foods.

2,544,572. Felt conditioner for use in papermaking. Frederick W. Vickery, assignor to Vickerys Ltd., London, England. Filed Nov. 16, 1948. 5 claims. (Cl. 92-50.) A felt-conditioner shoe contains jets for supplying cleaning fluid to the felt.

2,544,585. Adhesive of water remoistenable type from lignin sulphonic acid and polyvinyl alcohol and process involved in its preparation and use. Donald S. Bruce and Howard L. Heise, assignors to Gummed Products Co., Troy, Ohio. Filed Oct. 12, 1948. 3 claims. (Cl. 260-17.5.) An adhesive for laminating board consists of lignosul phonic acid and polyvinyl alcohol containing aluminum sulphate.

2,544,632. Repair of pulpstones. Norman F. Holter and

Walter F. Beth, assignors to Norton Co., Worcester, Mass. Filed Feb. 16, 1948. 2 claims. (Cl. 51-206.4.)

March 13, 1951

2,544,657. Pallet. Walton W. Cushman, Webb City, Mo. Filed Sept. 5, 1947. 3 claims. (Cl. 248-120.) The pallets consist of metal sheets spaced apart by a cellular paper body.

2,544,691. Coating composition comprising copolymers of acrylic esters and dicarboxylic acid esters. Joseph H. Kugler and William E. Lundquist, assignors to Minnesota Mining & Manufacturing Co., St. Paul, Minn. Filed Dec. 23, 1943. 9 claims. (Cl. 260-29.6.)

2,544,692. Pressure-sensitive adhesive tape. Joseph H. Kugler and William E. Lundquist, assignors to Minnesota Mining & Manufacturing Co., St. Paul, Minn. Filed April 2, 1949. 4 claims. (Cl. 117-122.) A paper or other backing is coated with a copolymer of 100 parts of isobutyl acrylate and 5 to 10 parts of di-2-ethylbutyl fumarate.

2,544,887. Manufacture of waterproof paper. Arthur G. Leonard, Jr., Wilmington, Ill. Filed May 18, 1946. 2 claims. (Cl. 92-21.) Impregnated cellulose wadding consists of waste corrugated boxes, about 7% of their weight of Vinsol-type resin, about 6% of an asphalt emulsion, and clay.

2,544,971. Paper stock refining machine. Harold D. Wells, Glens Falls, N. Y. Filed Sept. 17, 1947. 6 claims. (Cl. 92-27.) A jordan incorporates rigid piping for conducting stock into and from the shell.

2,544,999. Method of producing vanillin. Harry B. Marshall and Charles A. Sankey, assignors to The Ontario Paper Co. Ltd., Thorold, Ont., Canada. Filed Aug. 8, 1947. 5 claims. (Cl. 260-600). A method of oxidizing sulphite waste liquor to produce vanillin.

2,545,260. Apparatus for regulating power used by pulp grinders. Lorne A. Cole, Brantford, Ont., Canada. Filed June 3, 1948. 12 claims. (Cl. 60-97.)

2,545,266. Apparatus for coating webs. Charles A. Dickhaut and Benjamin R. Newcomb, assignors to John Waldron Corp., New Brunswick, N. J. Filed March 13, 1946. 11 claims. (Cl. 91-18.) The apparatus incorporates an air blast which serves to doctor the excess coating composition from the web.

2,545,389. Method for increasing the sulphur dioxide content of the cooking acid used in the manufacture of sulphite pulp. Väinö H. Somer and Tor E. Brehmer, assignors of one half to Somer and one half to Aktiebolaget Kaukas Fabrik, Lauritsala, Finland. Filed Oct. 26, 1946. 3 claims. (Cl. 23-129.) A portion of the gas supply is diverted and the sulphur dioxide therein is absorbed by 2-aminocymene; this is decomposed and the concentrated sulphur dioxide is introduced in the cooking acid.

March 20, 1951

2,545,589. Collapsible carton. Rolf A. Samsing, Dorchester, Mass. Filed Dec. 12, 1947. 4 claims. (Cl. 229-28.) A tray with a double row of compartments for fruit and the like.

2,545,603. Paper-covered wood product and method of making same. Ralph J. Byers and Moss B. Christian, assignors to Chicago Mill and Lumber Co., Chicago, Ill. Filed Dec. 22, 1947. 5 claims. (Cl. 154-132.) A method of making a paper-wood veneer.

2,545,802. Hinged lid automatic box. Samuel Bergstein, assignor to Robert M. Bergstein and Frank D. Bergstein, trustees. Filed Oct. 8, 1945. 5 claims. (Cl. 229-31.) A liquid-tight frozen food container.

2,545,803. Partitioned carton. Robert M. Bergstein, Wyoming, Ohio. Filed Aug. 12, 1947. 17 claims. (Cl. 229-28.) A folding carton incorporates partition elements which are raised automatically on setting up the carton.

2,545,832. Method for manufacturing laminated articles. John H. Wagers and Edward C. Shokal, assignors to Shell Development Co., San Francisco, Calif. Filed Aug. 27, 1945. 2 claims. (Cl. 154-95.) A laminate is formed from cellulosic fibers and the polymer of a diallyl ester of a dicarboxylic acid; the process is outlined.

2,545,912. Container spinning machine. John R. Baumgartner and John G. Bell, assignors to Morris Paper Mills, Chicago, Ill. Filed June 4, 1949. 2 claims. (Cl. 93-36.5.) A device for forming rolled edges on containers.

2,545,917. Drainage device for drum driers. James C. Cowie, assignor to Mersey Paper Co., Ltd., Brooklyn, N. S., Canada. Filed June 19, 1948. 4 claims. (Cl. 34-124.) A conventional siphon is used for the removal of the water. In addition, a stationary blade is suspended in the drum and is situated approximately parallel to the longitudinal axis of the drier; this assists in the drainage of the water.

2,546,137. Method and apparatus for making lined containers. David Schmidt, assignor to The Dobeckmun Co., Cleveland, Ohio. Filed Nov. 6, 1942. 4 claims. (Cl. 93-36.01.) A cylindrical container is lined with a loose, preformed, tubular, nonfibrous liner.

March 27, 1951

2,546,266. Apparatus for making insulation batts and boards. William J. Kropp, Wichita, Kan. Filed Oct. 20, 1948. 1 claim. (Cl. 154-27.) The product is formed from shredded paper or board and an adhesive.

2,546,376. Pulp beater. Walter N. Sherwood, Eagle Bridge, N. Y. Filed Oct. 20, 1945. 6 claims. (Cl. 92-22.) The bedplate cooperates directly with the roll throughout a distance approximating the diameter of the roll; no bedplate boxes are required.

2,546,542. Snap seal fastener. George C. Hurt, Warrentown, Ore. Filed Oct. 20, 1947. 2 claims. (Cl. 229-78.) A fastener for an envelope.

2,546,618. Process for impregnating fiber sheets. Pierre A. Talet, assignor to Societe Nobel Francaise, Paris, France. Filed April 29, 1948. 3 claims. (Cl. 154-140.) Paper is impregnated with polyvinyl alcohol, dried, and then immersed in a mixture of formaldehyde and sulphuric acid to convert the alcohol to the acetal.

2,546,621. Paper cup making machine. Paul E. Wixon and Clarence E. Chapman, assignors to Joseph Shapiro, Baltimore, Md. Filed Jan. 6, 1948. 8 claims. (Cl. 93-39.3.)

2,546,654. Contrivance for determining the degree of beating of fiber mass suspensions. Thor G. Qveflander, assignor to A. Ablstrom Osakeyhteo, Karhula Bruk, Finland. Filed Jan. 24, 1947. 10 claims. (Cl. 73-63.)

2,546,698. Sheet material with weakened tearing line. Charles Nicolle, Gentilly, France. Filed Dec. 26, 1945. 4 claims. (Cl. 229-66.)

2,546,705. Method of laminating polyvinyl alcohol film to paper and product. Jay F. Strawinski, Philadelphia, Pa. Filed Aug. 19, 1947. 10 claims. (Cl. 154-124.) The laminate contains an intermediate layer of plasticized polyvinyl alcohol film.

2,546,749. Treatment of pulp. Judson H. Holloway, Robert S. Tabke, and Arthur N. Parrett, assignors to Rayonier, Inc., Shelton, Wash. Filed May 1, 1946. 5 claims. (Cl. 260-212.) Mercerized wood pulp with a moisture content of not over 6% is ground in contact with acetic acid.

2,546,873. Carton taping machine with steam moistener for the tape. Albert F. Shields, assignor to S & S Corrugated Paper Machinery Co., Inc., Brooklyn, N. Y. Filed Dec. 9, 1947. 5 claims. (Cl. 216-30.)

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Instrumentation Studies. LXVI. A Study of Photoelectric Instruments for the Measurement of Color: Reflectance and Transmittance

IX. The Densichron as a Reflection Meter

LEONARD R. DEARTH, WAYNE M. SHILLCOX, and J. A. VAN DEN AKKER

The Densichron is a new photoelectric instrument, designed primarily for densitometry, having such high sensitivity that it can readily be adapted to the measurement of reflectance. It is versatile in application. When equipped with a meter designed to give a linear relationship between the meter reading and the light intensity, the Densichron could be employed with any one of a variety of simple attachments permitting the measurement of reflectance. Such attachments could be relatively inexpensive because lenses and other optics (beyond filters) are not needed; another advantage lies in the fact that a very low-powered lamp will supply sufficient light for precise measurement. The model of Densichron used in this study (1949) suffers a linearity error which, although sufficiently small for the purposes of photographic densitometry, is much too large for the accurate measurement of reflectance. As might be expected, the effective wavelength of the instrumental response with a Wratten 49 filter is not the proper value for brightness determination, but it is shown to be possible to correct the effective wavelength through the use of a suitable corrective filter. When this is done and when corrections are made for nonlinearity, proper brightness values of paper are obtained. (This procedure is not recommended in the application of the Densichron to the mill control of brightness.) The method of specific calibration is described, and it is shown that, when used with this method, the Densichron correctly indicates the variability of brightness of paper, with a standard deviation essentially the same as that calculated from data on standard brightness.

THERE has long been a need for a reflection meter which is inexpensive, yet sufficiently accurate and precise to be of value in the mill control of brightness of pulp and paper. The sensitivity of inexpensive instruments has always been a difficult problem; for example, adequate (but erroneous) meter response has often been obtained in cheap instruments through the use of improper optical filters or of peculiar, nonstandard geometries of illumination and viewing of the specimen. One of the first reflection meters examined on the American Paper and Pulp Association's instrumentation program was found to utilize both these circumventions of well-established principles.

If an instrument is very sensitive and also precise, linear, and stable in its response, it should be possible to use it as the basis for a satisfactory reflection meter by selecting a suitable geometry, source of light, and filter system. The Densichron* was considered to be sufficiently promising with regard to these requirements to justify its study in the APPA program. This photoelectric instrument, which was designed primarily although not solely for the measurement of photographic density, is relatively quite inexpensive. Its sensitivity is very much greater than that of ordinary photoelectric instruments, being not a great deal less than that of the photomultiplier tube (the most sensitive of all photoelectric devices excepting the photoelectric Geiger-Müller tube). No batteries are used and, when the instrument is operated on a 60-cycle frequency-controlled line (e.g., any major utility system), its deflection is stable. The accuracy of the instrument when used as a densitometer is apparently adequate; but a higher order of accuracy is required in the measurement of color and papermaker's brightness. The examination of the accuracy of the Densichron is the purpose of the present work.

A brief description of the Densichron will suffice for our present purposes; the technical reader may wish to refer to Kalmus and Striker (*1*) for basic considerations. The phototube (S-4 spectral response) is located in a 60-cycle alternating magnetic field. The tube and the a.c. magnet are located in the probe unit, which may be seen in the photograph of the Densichron given in Fig. 1. Photoelectrons ejected by light from the cathode of the phototube travel in paths that are strongly curved because of the interaction with the magnetic field; when the magnetic field strength is greater than a certain value, the paths are such that the electrons cannot be collected by the anode, and no photoelectric current is received by the amplifier (contained in the larger unit, Fig. 1). However, during short intervals of time centering on the points at which the magnetic field is zero, most of the photoelectrons are collected by the anode. Accordingly, the amplifier receives 120 pulses per second, for which frequency the amplifier is tuned.† Much greater amplification is possible with a tuned a.-c. amplifier than with a d.-c. amplifier. As a result, the Densichron has very high sensitivity. The Magnephot is designed and adjusted so that the instrumental response to steady illumination will be nearly constant when the line voltage varies through fairly large excursions, if the line frequency is constant.

The instrument is usually fitted with a meter having

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* Made by the W. M. Welch Manufacturing Co., 1515 Sedgwick St., Chicago 10, Ill.

† Magnephot is the manufacturer's name for the combination of the a.-c. magnet, phototube, and electronic circuit.

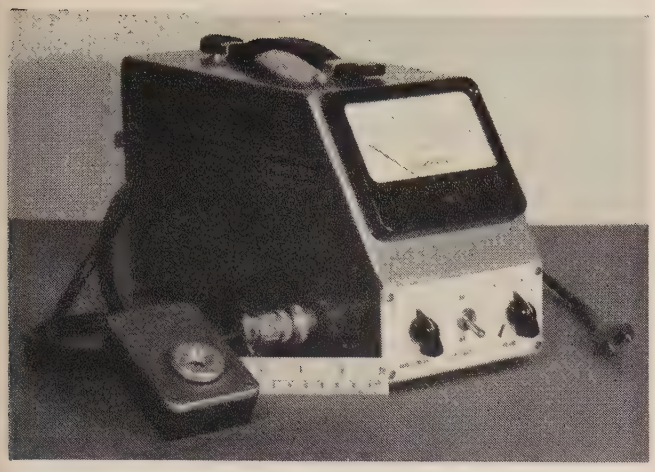

Fig. 1. The Densichron

a nonlinear response and a logarithmic scale, so that photographic density may be read directly from the meter. However, the Densichron can be furnished with a linear meter or, if desired, an auxiliary linear meter which may be plugged into the instrument. The latter arrangement is, of course, the more versatile of the two, and is the one which the manufacturer supplied to us.‡

The Densichron is equipped with a range switch covering four decades of sensitivity and a continuously adjustable "volume control" which covers one decade; thus, the over-all control is 10,000 to 1. Several apertures and fittings are supplied for use with the probe in the various applications of the instrument.

A recent piece of auxiliary equipment, of tentative design, enables one to measure reflectance with filtered light. This reflectance attachment is shown in Fig. 2. It should be stated that the success or failure of the Densichron as a reflection meter does not rest on the qualities of this attachment; it is obvious that a wide variety of designs of such auxiliary equipment should exist—all of them satisfying certain basic requirements—and it is possible that some users of the Densichron would wish to improvise their own reflectance attachments. The tentative reflectance unit shown in Fig. 2 contains two tunnels: one, arranged at 45° with the vertical, is for illumination and contains a tiny lamp with a refracting envelope (of the kind employed in a "penlight"); the other is arranged vertically over the illuminated spot and serves to pass reflected light to the phototube. A small filter wheel serves to place any desired filter across the paths of accepted reflected rays. No lenses are employed; the surface of the vertical tunnel is figured and blackened to eliminate rays striking the wall, and the tunnel is equipped with small apertures that delimit the reflected beam. A simple, inexpensive arrangement of this sort is possible because of the great sensitivity of the Densichron.

The probe is connected to the electronic unit with a flexible rubber-covered cable, so that the unit may be used in any orientation. The preferred manner of use of the reflectance unit is such that the device is laid upon the paper or other surface whose reflectance is to be measured. As in the operation of all direct-deflection methods, the device is placed first upon a standard and the response of the instrument and/or the light intensity is varied to obtain a reading equal to the known reflectance of the standard. The unit is then placed upon the test specimen and the reflectance is read from the meter. A fundamental discussion of this and other photometric methods has been given in Part I of this series (*2*), to which reference may be made for theoretical discussions of spectral, geometrical, and photometrical factors and errors.

‡ The linear meter is especially adapted to the Magnephot circuit with respect to sensitivity, resistance, and current-coil angle relationship; a user of the Densichron should not attempt to plug in just any d.-c. meter of suitable sensitivity.

RESULTS

Linearity of Response of the Densichron

Although a nonlinear instrument can be employed as a reflection meter if a special calibration procedure is used (as described later in this report), a device which yields an indication in accurate, direct proportion to the accepted light flux is more generally useful and reliable. The linearity of the Densichron was studied in two ways.

The preferred method for checking linearity was based on the use of the variable sector photometer of a G.E. reflection meter (GERM). The Densichron probe was fixed in the position normally occupied by the "active" PJ-22 phototube of a GERM. The window of the probe was fitted with a $^{9}/_{32}$-inch black paper aperture, and the exit aperture of the GERM was covered with a piece of flashed glass to obtain still better diffusion of light than normally exists. The flashed side of the diffusing glass was placed in contact with the bottom side of the exit aperture. The sample aperture of the GERM was covered with a block of magnesium carbonate, and steady illumination was obtained by operating the lamp on a suitable voltage regulator (a.c.).

With the photometer dial of the GERM set at 100.0, the response of the Densichron was adjusted to obtain a reading of 100 divisions on the linear meter (full-scale). The relative quantity of light entering the Densichron probe could then be fixed by setting the dial of the GERM to any desired value between 0 and 100; if the Densichron were linear, its indication should be numerically equal to the dial reading. A number of readings were made for the instrument studied (Serial No. 9484) and the results obtained are given in Table I. The first column gives the GERM settings; the next five columns give the Densichron readings for range 2 and sensitivity settings (on the continuously adjustable

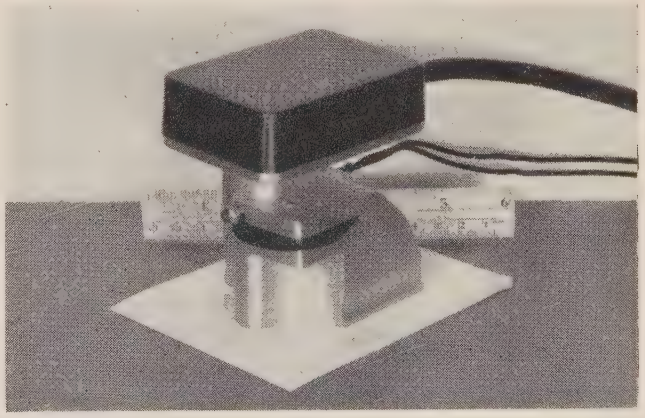

Fig. 2. The Densichron reflectance attachment with the probe unit mounted on top. The specimen is under the device

Table I. Linearity Test of the Densichron from Arbitrary Units

Dial setting, GERM	2	4	6	8	10
			Range 2		
100.0	100.0	100.0	100.0	100.0	100.0
90.0	90.9	91.3	91.5	91.0	91.2
80.0	80.9	82.0	82.2	81.8	81.3
70.0	71.1	72.8	72.8	71.7	71.0
60.0	61.8	63.3	63.2	61.8	61.5
50.0	52.3	53.9	53.6	51.4	51.3
40.0	43.4	44.1	43.5	41.9	41.8
30.0	33.3	33.5	32.8	31.3	31.2
20.0	23.2	22.5	21.7	21.0	21.2
10.0	12.0	11.2	11.0	11.0	11.0
0.0	0.0	0.0	0.0	0.0	0.0
			Range 3		
100.0	100.0	100.0	100.0	100.0	100.0
90.0	90.7	91.1	91.3	91.3	91.5
80.0	80.7	81.5	81.8	82.2	82.3
70.0	70.2	72.0	72.0	72.9	73.3
60.0	60.8	62.5	62.8	64.0	64.8
50.0	50.8	52.9	53.3	54.8	55.1
40.0	41.3	43.3	44.0	45.5	46.2
30.0	31.2	33.3	34.5	35.8	36.2
20.0	21.2	23.5	24.3	25.1	25.3
10.0	11.2	12.9	13.1	14.2	14.4
0.0	0.0	0.0	0.0	0.0	0.0

control) 2, 4, 6, 8, and 10; in the bottom half of the table, the first row is again the GERM settings, and the remaining five columns are for range 3 and sensitivity settings 2, 4, 6, 8, and 10. Light intensity was varied by means of screens and apertures in the incident light beam of the GERM to obtain data at the ten different response settings.

The data of Table I show that the Densichron response is, unfortunately, badly nonlinear (relative to the level of accuracy required in colorimetric work and in brightness determination). Depending upon the response setting of the instrument, the error might be as large as 6 divisions or, expressed as a percentage, 10% in the middle of the range and more than 20% in the low part of the range. Data reported below support the curious result that the error depends upon the response settings of the instrument.

A number of tests were made in an effort to explore the variability of the deviations from linearity as it might depend upon the size of the aperture over the phototube in the probe and upon certain other factors. These tests were all made with a standard screen, whose transmission has been calculated to be 42.4% and measured at 42.5%. The experimental setup was entirely different from that employed to give the data presented in Table I. The IPC transparency meter (*3*) was used to produce a steady, nearly parallel beam of light. This beam was admitted to an integrating cube through a circular port. Two other ports, whose axes were mutually at right angles and at right angles with the axis of the beam, were located in two of the faces of the cube; one of these was covered with the probe of the Densichron, and the other was covered with a Weston blocking-layer photocell (type 3, color code yellow, red). The Weston photocell was used in a "zero-resistance" circuit, which is known to be linear, and the galvanometer had been tested for linearity and was known to be accurately linear. A check of the latter arrangement was made with the screen and agreement to within 0.1% was obtained. The data obtained with the Densichron are presented in Table II. The numbers appearing in the first column are the experiment numbers. The serial numbers of two Densichrons studied are given in the second column; brief notes are also given in this column. The aperture size appearing in the third column is the diameter of a black paper aperture placed over the window of the probe. As in Table I, the remaining columns present the data for various sensitivity settings.

Incomplete data were obtained in the first experiment, because it was discovered that the transmission value was influenced by gentle tapping of the probe. The inner connections were examined and found to be sound. However, an electrical shield, comprised of a strip of thin brass sheet wrapped part way around the phototube, cut the magnetic lines of force and completed a simple loop circuit by contact with the case, so that an eddy current—perhaps of an erratic nature because of the casual contact—could have been induced. Thinking that this might be connected with the variable results induced by tapping, the shield was insulated from the case and the data given for Experiment 2 were observed. The shield was then returned to its original condition (Experiment 3), and no substantial modification was observed. Variability resulting from tapping has not since been observed, and it seems probable that (as is so often the case) the defect was eliminated simply by removing and replacing the cover of the probe. Experiments 3 to 8 show that both the aperture size and the response setting of the instrument influence the deviation from linearity. The last two of this series (experiments 7 and 8) show that the phenomena are reproducible. Observations with a second Densichron (experiments 9 and 10) indicated similar but numerically different behavior. The manufacturer has found that, in certain cases, the quality of linearity could be modified through changes in a certain capacitor (C_{12}) in the electronic circuit, by selecting the 6SN7 tubes, and by reversing the electrical leads to the magnet (which changes the phase of the magnetic field and of any induced electrical currrents by 180°). In this instance, changes in the capacitance, replacement of the two 6SN7 tubes with new ones supplied by the manufacturer, and reversal of the magnetic field failed to improve the situation.

It is evident that the Densichron, in its present state of development, could be used as a control brightness tester only under carefully regulated conditions. For example, having fixed upon an optimum aperture size, it would be necessary to set the instrumental response controls at fixed, optimum values, and employ a special calibration system.

Effective Wavelength of the Densichron Response When Used with a Wratten 49 Filter

The phototube of the Densichron has an S-4 spectral response, which is different from that of the PJ-22 phototube employed in the GERM. Accordingly, one would expect the effective wavelength of the instrumental response (with a Wratten 49 filter) to be different from that of the GERM, which latter is 457 mmu. Using the arrangement employed for the observation of the linearity data given in Table I—i.e., with the probe located in the GERM in place of the PJ-22 phototube—the effective wavelength was determined by our regular procedure (*4, 5*). In this determination, the Densichron was used as a null detector, so that errors due to nonlinearity would be absent, and the result should de-

Table II. Influence of Various Factors on the Apparent Transmission of a Standard Screen
Deviations from the Correct Value (42.5%) Are Given Under Each Result

Experiment	Serial	Aperture diameter, in.	Range 2				Range 3		
			2	4	6	8	2	4	6
1	9484	3/32	...	...	...	...	45.3	42.0	...
	...	...	...	...	...	...	+2.8	−0.5	...
2	Shield insulated	3/32	44.5	45.7	43.3	40.2	38.7	42.0	44.2
	...	...	+2.0	+3.2	+0.8	−2.3	−3.8	−0.5	+1.7
3	Shield shorted	3/32	44.6	45.4	43.9	40.5	38.7	41.8	44.3
	...	...	+2.1	+2.9	+1.4	−2.0	−3.8	−0.7	+1.8
4	...	5/32	44.7	48.0	48.2	44.7	39.8	39.0	41.7
	...	...	+2.2	+5.5	+5.7	+2.2	−2.7	−3.5	−0.8
5	...	9/32	45.1	47.1	45.8	43.7	42.2	42.3	43.8
	...	...	+2.6	+4.6	+3.3	+1.2	−0.3	−0.2	+1.3
6	...	15/32	47.3	45.5	43.5	42.8	43.0	44.9	46.2
	...	...	+4.8	+3.0	+1.0	+0.3	+0.5	+2.4	+3.7
7	...	3/32	44.4	45.8	43.4	...	37.8	42.0	44.0
	...	...	+1.9	+3.3	+0.9	...	−4.7	−0.5	+1.5
8	...	9/32	45.2	46.6	45.7	...	41.9	42.0	...
	...	...	+2.7	+4.1	+3.2	...	−0.6	−0.5	...
9	94212	9/32	45.2	45.1	46.1	...	45.5	41.0	40.9
	...	...	+2.7	+2.6	+3.6	...	+3.0	−1.5	−1.6
10	...	3/32	...	44.4	45.3	...	44.0	37.9	39.1
	...	...	...	+1.9	+2.8	...	+1.5	−4.6	−3.4
11	9484	3/32	43.5	45.8	44.7	...	38.2	40.9	43.2
	C_{12} = 0.047 mfd.	...	+0.9	+3.3	+2.2	...	−4.3	−1.6	+0.7
12	...	3/32	43.6	45.7	45.1	...	38.2	41.2	43.1
	C_{12} = 0.141 mfd.	...	+1.1	+3.2	+2.6	...	−4.3	−1.3	+0.6
13	Replaced both 6SN7	3/32	45.3	48.4	50.0	...	35.1	36.8	39.8
		...	+2.8	+5.9	+7.5	...	−7.4	−5.7	−2.7
14	Magnetic field reversed	3/32	45.1	48.7	48.0	...	38.3	38.5	41.3
		...	+2.6	+6.2	+5.5	...	−4.2	−4.0	−1.2

pend only on the spectral qualities of the phototube. The effective wavelength was found in this manner to be 460 mmu.

A liquid filter was then prepared to compensate for the difference between the spectral response curves of the PJ-22 and the CE34R phototubes. A filter cell containing an aqueous solution of auramine and cobalt sulphate (having a transmission curve that decreases as the wavelength increases from 400 to 500 mmu) was adjusted so that approximately the proper effective wavelength would be obtained when the filter cell was placed between the sample aperture of the GERM and the condensing lenses. The result was then 456 mmu, which was judged to be sufficiently close to the proper value to warrant further observations.

Using the corrective filter, it seemed of interest to determine if correct values could be obtained for the brightness of papers, employing the GERM with the corrected Densichron probe as the null detector. The average values for 14 papers are given in Table III The excellence of agreement is strongly indicative of the success that could be achieved with the Densichron as a brightness tester, were the instrument to be subjected to spectral and photometrical correction. This conclusion was further verified by a series of measurements for which the Densichron (spectrally corrected) was used as a direct-reading instrument. The optical system of the GERM was employed for convenience. Readings were now taken from the Densichron meter instead of from the dial of the GERM, with the results given in Table IV. The first column presents the standard brightness, the second column the brightness as read directly from the Densichron meter, and the third column the Densichron brightness corrected for nonlinearity. The conditions of the test were accidentally such that the photometric error of the Densichron was relatively small. In addition to the good agreement between the corrected results and the standard brightness, the individual readings, of which average values are given in Table IV, demonstrated good correspondence with those for the same specimens determined in the usual way with the GERM. That is to say, the Densichron measured the variability of the paper in a reliable manner. It will be understood, however, that the conditions for the good agreement shown in Tables III and IV were optimum, and the data indicate the quality of results that could be obtained with the Densichron if it were fully corrected and used with a suitable optical system.

Table III. Brightness Determined with the GERM, Using the Spectrally Corrected Densichron Probe as Null Detector
Magnesium Carbonate Standard[a]

Standard brightness, %	Brightness with GERM using Densichron probe, %
51.3	51.2
51.4	51.3
60.3	60.0
60.5	60.2
69.9	69.9
70.0	70.1
74.5	74.6
74.5	74.7
83.4	83.4
83.8	83.6
84.7	84.7
85.1	85.0
87.5	87.5
87.7	87.5

[a] The particular $MgCO_3$ is equivalent to MgO in brightness.

Experiments with the Reflectance Attachment

The Densichron reflectance attachment shown in Fig. 2 was used to measure the blue reflectances of several papers, with the results shown in Table V. The first column presents the standard brightness. The second column gives the averages of readings obtained

Table IV. Comparison of Brightness Determined with the Densichron as a Direct Reading Instrument with Standard Brightness[a]

Densichron Spectrally Corrected; Standard[b]	Magnesium Carbonate
Standard brightness, %	*Densichron brightness, %*	*Densichron brightness (corrected),[c] %*
23.5	26.6	23.4
49.1	50.4	49.1
60.5	61.2	60.3
66.1	66.8	66.3
69.6	71.0	70.0
73.6	74.3	73.9
77.0	78.2	77.7
84.8	86.0	84.9
87.2	87.9	87.1

[a] Each value is the average of five readings.
[b] The particular $MgCO_3$ is equivalent to MgO in brightness.
[c] Corrected for nonlinearity.

when a Wratten 49 filter was used in the reflectance attachment in place of the blue filter normally supplied with the unit, and the remaining columns present the readings obtained with the unit as received, with the lamp operating at 4.6, 6.2, 7.2, and 8.9 volts (the lamp is furnished with alternating current from a small transformer).

It will be seen that the combination of the CE34R phototube and the Wratten 49 filter, under the conditions of normal operation of the lamp at about 8.9 volts (column 2) gave rise to low values. The blue filter supplied with the unit was replaced and reflectances were obtained at various lamp voltages (columns 3, 4, 5, and 6). In studying the data so obtained, it must be remembered that, as the lamp voltage increases and the effective wavelength decreases, the response settings of the instrument (range and continuous sensitivity control) also varied, thus causing the linearity error to change. Evidently the combination of 7.2 volts across the lamp with range 2 and sensitivity 6 resulted in fair agreement *for the particular instrument employed*. It is not possible to say from this result that all other Densichrons could be made to yield good agreement through adjustment of the lamp voltage; on the contrary, it is conceivable that the constants of another Magnephot might be such that the shift in effective wavelength associated with a change in lamp voltage could not be made to compensate (for typical "white" papers) for the linearity error. The good agreement indicated in the fifth column of Table V is tentatively regarded as accidental, insofar as generalization of the results to other Densichrons is concerned.

Table V. Blue Reflectance Obtained with the Densichron Reflectance Unit[a]

Magnesium Carbonate Standard[b]

Standard brightness, %	*Densichron with Wratten 49, lamp at 8.9 v., range 2, sensitivity 6, %*	*Reflectance unit as received — Lamp at 4.6 v., range 3, sensitivity 6, %*	*Lamp at 6.2 v., range 3, sensitivity 2, %*	*Lamp at 7.2 v., range 2, sensitivity 6, %*	*Lamp at 8.9 v., range 2, sensitivity 3, %*
23.4	20.4	23.5	20.0	21.6	23.1
48.8	45.9	47.2	45.0	48.5	49.7
60.1	57.8	58.0	56.8	60.1	60.6
66.0	64.4	63.7	63.0	66.3	66.3
69.5	68.8	67.7	67.0	69.3	70.0
73.5	72.3	71.0	70.8	73.6	73.9
76.9	76.2	75.5	75.7	77.3	77.4
84.6	84.0	83.8	83.0	84.6	85.1
87.1	87.0	87.0	86.3	87.7	87.5

[a] Each value is the average of five readings.
[b] The particular $MgCO_3$ is equivalent to MgO in brightness.

Observations with the Densichron, Using a Special Calibration Procedure

If a reflection meter suffers a linearity error and fails to meet such other requirements as those of effective wavelength and geometry of illuminating and viewing of the specimen, but if, also, *the instrument is not grossly in error with respect to these important requirements*, the following method of calibration should lead to accurate results. We may term the procedure *specific calibration*, because it is valid only for the kinds of papers encompassed by the procedure.

Specific calibration should be employed wherever a nonstandard reflection meter is used for the measurement of brightness. Let is be supposed that a mill produces different kinds of paper A, B, etc., and that the mill laboratory makes handsheets of pulps or blends of pulps M, N, etc., the brightness values of which are to be determined. Differentiation is here based primarily on furnish and surface characteristics. For each working standard (e.g., tile block, enameled plate, etc.) there should be an entry sheet; as a matter of convenience, this sheet may be cemented to the back of the working standard. The first column on the sheet should designate the various papers and pulps (A, B, . . . M, N, . . .). The standard is then evaluated by means of a *paper standard* prepared from paper A (i.e., an opaque pile of sheets of paper A with the machine direction designated with an arrow, and with the felt side—the side to be tested—designated). The paper standard is itself evaluated shortly before this work by means of a standardized G.E. reflection meter (*5*). The value obtained for the working standard *on the instrument to be used* (for example, a Densichron) is entered upon the sheet opposite the designation of paper A. This procedure is repeated for a paper standard prepared from paper B, and so on. The several values obtained for the working standard will all be different. The consistency of the values will depend upon the quality of the nonstandard reflection meter. If it conforms closely to the standard requirements (*5*), all the values will be very nearly the same; if it deviates badly from those requirements, as is the case with the Densichron in its present stage of development, the total spread covered by the values would be several units of reflectance.

In using the working standard, the instrument is set on the value corresponding to the kind of paper whose brightness is to be measured (by adjustment of light intensity or response, or both). The brightness of the paper is then measured.

Theoretically, the instrument cannot be used to measure the brightness of a paper or pulp for which the standard has not been evaluated. If the sample is similar to one of the set in furnish, surface characteristics, and brightness, the error involved may not be large. The extent to which one may extend the use of the instrument to papers for which the specific calibration has not been applied will depend upon the conformity of the instrument to the standard requirements.

In applying the specific calibration procedure, one should bear in mind that the color of paper is fugitive, especially during the first few months following manufacture. Accordingly, the paper standards should be prepared from paper that is at least several months old.

The working standard will also exhibit changes with time, so that the specific calibration should be repeated at reasonably frequent intervals.

It was felt to be of interest to apply the specific calibration method to the Densichron, mainly with the objective of determining the ability of the instrument faithfully to indicate the variability of brightness that is exhibited by all papers. Actually, the method was simulated by working with the paper standards directly; as opposed to mill control work, where paper standards would become soiled in a short time, our test involved relatively few determinations with any one paper standard, and no soiling was instrumentally observable.

Eight papers were used in this test. Each paper standard was composed of a number of specimens, 20 of which were individually measured with the GERM and with the Densichron reflectance attachment (as received). After evaluating a given paper standard with the GERM, the Densichron was set by means of the standard, and the readings for all 20 specimens were then taken without further reference to the standard. It was found possible to make these readings sufficiently fast so that no appreciable drift of the instrument occurred during the 20 measurements, as indicated by a check against the standard setting at the end of the series. If the final check showed that the standardization had not held for the series, the values were rechecked.

The setting of the Densichron upon the standard values was obtained by adjusting the lamp voltage and response settings. The approximate lamp voltages and response settings are given at the heads of the columns of Densichron readings in Table VI, which presents the results for the series of eight papers. The first two columns compare the reflectances obtained with the GERM and the Densichron for the individual sheets (backed, of course, by the remaining sheets) of the first sample, whose brightness was 50.7%. The standard deviation given under each average value is that computed for the individual readings. Inspection of the results for the eight pairs of columns shows that the Densichron, using the specific calibration procedure, (a) yields average reflectance very nearly equal to that determined with the GERM, (b) follows the individual sheet variations in brightness rather well, (c) may be

Table VI. The Densichron as a Brightness Tester, Using a Special Calibration Procedure

	Paper 1		*Paper 2*		*Paper 3*		*Paper 4*	
	GERM	*Densichron lamp at 8.2 v., range 2, sensitivity 6*	*GERM*	*Densichron lamp at 8.2 v., range 2, sensitivity 6*	*GERM*	*Densichron lamp at 8.2 v., range 2, sensitivity 6*	*GERM*	*Densichron lamp at 8.2 v., range 2, sensitivity 6*
	50.7	50.7	23.6	23.6	66.3	66.3	60.2	60.2
	50.7	50.9	24.0	23.8	66.0	65.5	60.4	60.3
	50.7	50.9	23.5	23.2	67.0	67.2	60.4	60.4
	50.5	50.9	23.3	23.0	66.9	67.1	60.7	60.3
	51.0	51.0	23.2	23.1	66.8	66.9	60.3	60.2
	50.4	51.0	23.4	23.2	66.1	66.7	60.5	60.6
	50.7	51.0	23.4	23.1	67.0	67.0	60.0	60.0
	51.0	51.0	23.6	23.5	66.9	67.1	60.6	60.2
	50.9	51.0	23.6	23.5	66.9	67.0	60.4	60.2
	50.5	50.9	23.2	23.1	66.6	67.0	60.7	60.2
	50.7	50.5	23.6	23.8	66.8	66.8	60.3	60.1
	50.4	50.5	23.0	23.0	66.8	66.1	60.4	60.0
	50.9	51.0	23.3	23.1	65.8	65.8	60.6	60.3
	51.2	51.2	23.3	23.0	67.1	67.2	60.8	60.2
	50.6	50.6	23.3	23.1	67.1	67.0	60.6	60.2
	50.7	50.9	23.2	23.0	66.2	66.0	60.3	60.2
	51.0	51.0	23.7	23.4	65.6	65.2	60.3	60.2
	50.8	51.0	23.2	23.0	67.0	66.6	60.3	60.0
	50.8	50.8	23.9	23.8	66.7	67.0	60.3	60.0
	50.6	50.5	23.1	23.0	66.3	66.4	60.3	60.0
Av.	50.7	50.9	23.4	23.3	66.6	66.6	60.4	60.2
Std. dev.	±0.2	±0.2	±0.3	±0.3	±0.4	±0.6	±0.2	±0.2

	Paper 5		*Paper 6*		*Paper 7*		*Paper 8*	
	GERM	*Densichron lamp at 7.8 v., range 2, sensitivity 6*	*GERM*	*Densichron lamp at 7.8 v., range 2, sensitivity 6*	*GERM*	*Densichron lamp at 7.8 v., range 2, sensitivity 6*	*GERM*	*Densichron lamp at 7.8 v., range 2, sensitivity 6*
	69.7	69.6	74.1	74.2	76.8	77.0	83.2	83.2
	69.5	69.2	74.1	74.2	77.0	76.9	83.2	83.5
	69.4	69.3	74.4	74.5	76.9	76.8	83.0	83.2
	69.5	69.2	74.0	74.2	76.9	76.8	83.0	83.0
	69.6	69.4	74.1	74.2	77.0	76.9	83.0	83.0
	69.5	69.4	74.2	74.5	77.0	76.8	83.1	83.0
	69.6	69.4	74.2	74.3	77.1	76.9	83.1	83.0
	69.6	69.3	74.3	74.3	77.6	77.4	83.2	83.0
	69.4	69.1	74.3	74.3	77.1	77.0	83.1	82.9
	69.4	69.3	74.3	74.2	76.7	77.0	83.3	83.0
	69.5	69.5	74.4	74.3	76.9	77.3	83.1	83.0
	69.4	69.5	74.2	74.2	77.0	77.1	83.1	83.0
	69.4	69.6	74.3	74.2	77.0	77.0	83.1	82.9
	69.5	69.7	74.3	74.3	77.0	77.2	83.3	83.0
	69.1	69.4	74.3	74.1	76.8	76.9	83.1	82.9
	69.4	69.3	74.5	74.1	76.8	76.9	83.1	83.0
	69.3	69.1	74.3	74.1	76.7	76.9	83.1	83.0
	69.3	69.3	74.2	74.0	77.0	77.0	83.2	83.0
	69.5	69.7	74.0	73.9	77.0	77.0	83.0	83.0
	69.2	69.3	74.3	74.0	76.9	77.0	83.2	83.0
Av.	69.4	69.4	74.2	74.2	77.0	77.0	83.1	83.0
Std. dev.	±0.1	±0.2	±0.1	±0.2	±0.2	±0.2	±0.1	±0.1

read with fair precision, and (d) yields a standard deviation that is essentially the same as that obtained with the GERM. With regard to the last point, it seems to be clear that the major contribution to the standard deviation is the variability of the brightness of the paper.

The manufacturers of the Densichron state that they have made improvements in the linearity of response of the instrument.

CONCLUSIONS

1. Because of its remarkably great sensitivity, a Densichron can easily be adapted to the measurement of reflectance, only a simple attachment (without lenses) being necessary.

2. In its present stage of development, inaccuracies of the Densichron are such that the instrument may be used with a reflectance attachment to measure papermaker's brightness only when the method of *specific calibration* is employed.

3. The Densichron's response to a constant level of illumination is steady in spite of small variations in line voltage if the frequency of the line is constant at 60 cycles per sec.

4. The response of the instrument is nonlinear and the extent of the photometric error depends upon the size of the aperture over the phototube and upon the response settings of the instrument; the linearity error can be either positive or negative. If the aperture size and the response settings are fixed, the linearity error remains fairly constant.

5. It is possible to make spectral correction, through the use of filters, to adjust the effective wavelength of the Densichron to the proper value for brightness determination (457 mmu).

6. Using an optimum combination of lamp voltage and response settings, it was possible to obtain approximately correct brightness values for a series of papers, using the Densichron reflectance attachment as received. However, badly discordant data were obtained with other lamp voltages and response settings, and it does not seem probable that all Densichrons could be adjusted to yield correct brightness readings simply through adjusting lamp voltage and response settings.

7. Using the method of *specific calibration*, the Densichron (with the reflectance attachment) faithfully measured the variability of the brightness of several papers, and the standard deviations of the readings were essentially the same as those calculated from the readings obtained with the G.E. reflection meter.

8. Because of such attractive features of the Densichron as low cost, great sensitivity, and versatility of application, it is hoped that improvements will be made which will lessen or eliminate the linearity error.

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Paper and Packaging Specifications

UU-P-271b (revision), Paper, Wrapping, Waterproofed Kraft, Price, 5 cents.

This revision is based largely on the Joint Army-Navy Specification, JAN-P-125, Barrier-Materials, Waterproof, Flexible, with changes to bring the specification into accord with the current requirements of the military agencies of the Government. It was prepared with the assistance of these agencies and the Technical Committee of the Waterproof Paper Manufacturers Association. Requirements are specified for 18 classes of papers suitable for baling, interior wraps, crate liners, shrouds, crate tops, temporary tarpaulins, and case liners. The requirements specified include details of construction, tensile strength, stretch, water resistance, stiffness, tearing resistance, water-vapor permeability, and Beach puncture resistance.

UU-P-543c (revision), Paper, Stencilboard, Price, 5 cents.

The only important changes made were to bring the form into accord with the present form for Federal specifications and to incorporate revised packing and marking requirements for the military agencies.

UU-C-806c (revision), Cups and Lids, Paper, Cold-Drink, Price, 10 cents.

This was developed with the assistance of the Technical Committee of the Paper Cup and Container Institute, and has the approval of the Institute. The specification has been greatly amplified. It now covers eight styles of water cups, and 11 styles of cold-drink and carry-out cups with requirements for lids, and all standard sizes for each style. Requirements are specified for capacity, weight, resistance to leakage, and rigidity of the cups, and bursting strength and thickness of the paper. The paper is required to be free from groundwood pulp. The weight and thickness of lids are specified.

Tape, Masking; Paper (Pressure-Sensitive), UU-T-106a (revision), Price, 5 cents.

The specification has been rewritten to bring it into accord with the present form for Federal specifications, and a stiffness requirement, applicable to Army purchases only, has been added relative to the suitability of the tape for use with explosives. The primary use of the tape is to protect surface areas not to be covered with finishing materials such as paint, dope, and varnish.

Paper, Writing, UU-P-641b (revision), Price, 5 cents.

The specification has been rewritten to bring it into accord with the present form for Federal specifications, and the folding endurance and bursting strength requirements have been lowered. These are now in accord with the specification of the Government Printing Office.

Paper, Chart (Lithographic-Finish), UU-P-171b (revision), Price, 5 cents.

The specification has been rewritten to bring it into accord with the present form for Federal specifications. It covers paper to be used for printing nautical charts by multicolor lithography, from engraved copper, stone, aluminum, and zinc. Two grades, 100 and 50% cotton or linen fibers, are now included, and requirements for expansivity, brightness, and smoothness have been added.

Paper, Map (Lithographic-Finish), UU-P-361a (revision), Price, 5 cents.

The specification has been rewritten to bring it into accord with the present form for Federal specifications. It covers paper for printing maps by multicolor offset lithography. It now includes two types, high wet-strength and low wet-strength. The high wet-strength papers now include two grades of 24-pound paper, and one grade of 20-pound paper (17 × 22—500). The low wet-strength papers are in two grades, 50% cotton or linen and 100% chemical wood.

(A revision of the Federal Specifications Index, revised to Jan. 1, 1951, has been issued under the new title, "Federal Specifications and General Services Administration Specifications Index." This and Federal specifications may be obtained on application accompanied by postal note, money order, coupon, or cash to the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The price of the Index is 35 cents.)

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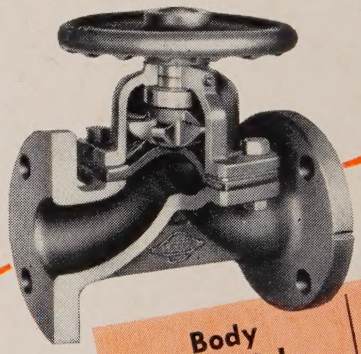
The Grinnell-Saunders Valve Division will be pleased to submit recommendations upon receipt of complete information covering service conditions.



We supplied Grinnell-Saunders Diaphragm Valves with . . .

Body Material	Diaphragm Material
1 Rubber lined	Natural rubber
2 Cast iron	KEL-F
3 Glass lined	Butyl
4 Magnesium	KEL-F
5 Polished bronze	White diaphragm
6 Cast iron*	Neoprene

*For oxygen service a low flash point lubricant is supplied. All valves for oxygen service are subjected to 300 lb. air underwater test.

Features of the Grinnell-Saunders Diaphragm Valve

- diaphragm absolutely isolates working parts from fluid
- diaphragm lifts high for streamlined flow in either direction
- diaphragm presses tight for positive closure
- body, lining and diaphragm materials to suit service
- simple maintenance—diaphragm easily replaced

GRINNELL

WHENEVER PIPING IS INVOLVED

Grinnell Company Inc., Providence, Rhode Island • Sales Offices and Warehouses in Principal Cities

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco humidification and cooling systems